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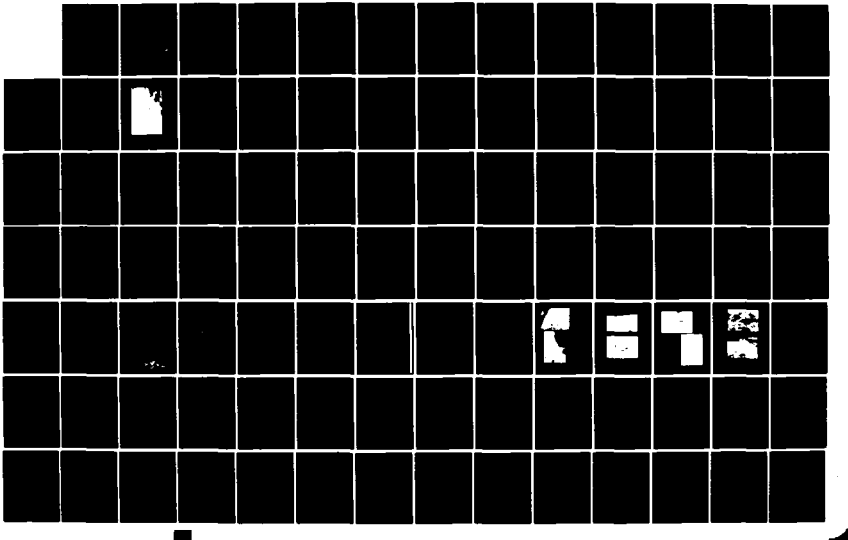

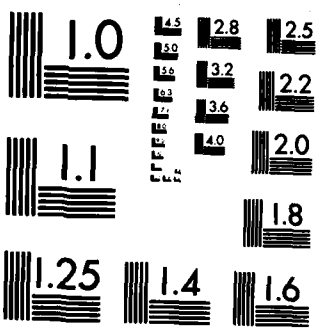

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MASSACHUSETTS COASTAL BASIN
SCITUATE, MASSACHUSETTS

FIRST HERRING BROOK RESERVOIR DAM
MA 00478

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

JULY 1981

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: MA 00478	2. GOVT ACCESSION NO.: AD-A154733
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): First Herring Brook Reservoir Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS	5. TYPE OF REPORT & PERIOD COVERED: INSPECTION REPORT
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254	12. REPORT DATE: July 1981 13. NUMBER OF PAGES: 59
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Massachusetts Coastal Basin
Scituate, Massachusetts
First Herring Brook

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The first Herring Brook Reservoir Dam consists of an earth embankment with a concrete core wall. The embankment has a top width of 20 ft. and a maximum height of 21.5 ft. The overall length of the dam is 700 ft., including a 42 ft. long concrete spillway. The dam is considered to be in fair condition. It has a size classification of small and a high hazard potential. It is recommended that the owner engage the services of a registered engineer to specify and oversee various procedures.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254

REPLY TO
ATTENTION OF:

NEDED

AUG 21 1981

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

Inclosed is a copy of the First Herring Brook Reservoir Dam (MA-00478) Phase I Inspection Report, prepared under the National Program for Inspection of Non-Federal Dams. This report is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. I approve the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is vitally important.

Copies of this report have been forwarded to the Department of Environmental Quality Engineering, and to the owner, Town of Scituate, MA. Copies will be available to the public in thirty days.

I wish to thank you and the Department of Environmental Quality Engineering for your cooperation in this program.

Sincerely,

WILLIAM E. HODGSON, JR.
Colonel, Corps of Engineers
Acting Commander and Acting Division Engineer

Incl
As stated

FIRST HERRING BROOK RESERVOIR DAM

MA 00478

MASSACHUSETTS COASTAL BASIN

SCITUATE, MASSACHUSETTS

PHASE 1 INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM

PHASE 1 INSPECTION REPORT

IDENTIFICATION NO.:		MA 00478
NAME OF DAM	:	FIRST HERRING BROOK RESERVOIR DAM
TOWN	:	SCITUATE
COUNTY AND STATE	:	PLYMOUTH COUNTY, MASSACHUSETTS
STREAM	:	FIRST HERRING BROOK
DATE OF INSPECTION:		DECEMBER 8, 1980

BRIEF ASSESSMENT

The First Herring Brook Reservoir Dam consists of an earth embankment with a concrete core wall. The embankment has a top width of 20 feet and a maximum height of 21.5 feet. The overall length of the dam is 700 feet, including a 42 foot long concrete overflow spillway near the center of the dam and a 3 foot wide concrete fish ladder about 35 feet to the left of the spillway. The outlet works consist of a 12 inch diameter ductile iron low level outlet through the earth embankment and core wall.

The dam impounds First Herring Brook Reservoir, a storage reservoir for public water supply for the Scituate Water Department. Maximum storage at the top of the dam is about 950 acre-feet.

Based on visual inspection and a review of all available pertinent data, the dam is considered to be in fair condition.

Features that could effect the structural integrity of the dam are seepage at the toe of the slope and at the downstream spillway training walls; animal burrows on the downstream slope, and diagonal cracks in the training wall at the weir crest.

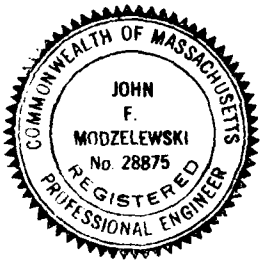
Based on the Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams, the dam is classified as "Small" in size, with a "High" hazard potential. A Test Flood which approximated one-half of the Probable Maximum Flood (1/2 PMF) was selected in accordance with the Corps of Engineers' Guidelines. The calculated test flood inflow of about 600 cfs results in a routed outflow of about 500 cfs. The Test Flood would not overtop the dam. The spillway discharges 100% of this flood with over 4 feet of freeboard remaining at the dam.

It is recommended that the owner engage the services of a qualified, registered engineer to specify and oversee procedures for patching cracks and plugging animal burrows; to investigate the cause of the wet area at the toe of the downstream slope and at the downstream end of the training walls; to design and oversee erosion protection for the upstream edge of the spillway crest and for the areas adjacent to the spillway training walls; to design an upstream control for the low level outlet.

Technical inspections by a qualified, registered engineer should be performed every year; the dam should be inspected visually once a month; a formal written maintenance program should be prepared and implemented; and a formal downstream warning system should be put into effect.

The owner should implement the recommendations as described herein and in greater detail in Section 7 of the Report within one year after receipt of this Phase 1 Inspection Report.

ASEC CORPORATION



John F. Modzelewski P.E.
Project Engineer/
Director of Engineering Services

This Phase I Inspection Report on First Herring Brook Reservoir Dam (MA-00478) has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

JOSEPH W. FINEGAN, JR., CHAIRMAN
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase 1 Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase 1 Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspection. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase 1 investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect

to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase 1 inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase 1 Investigation does <u>not</u> include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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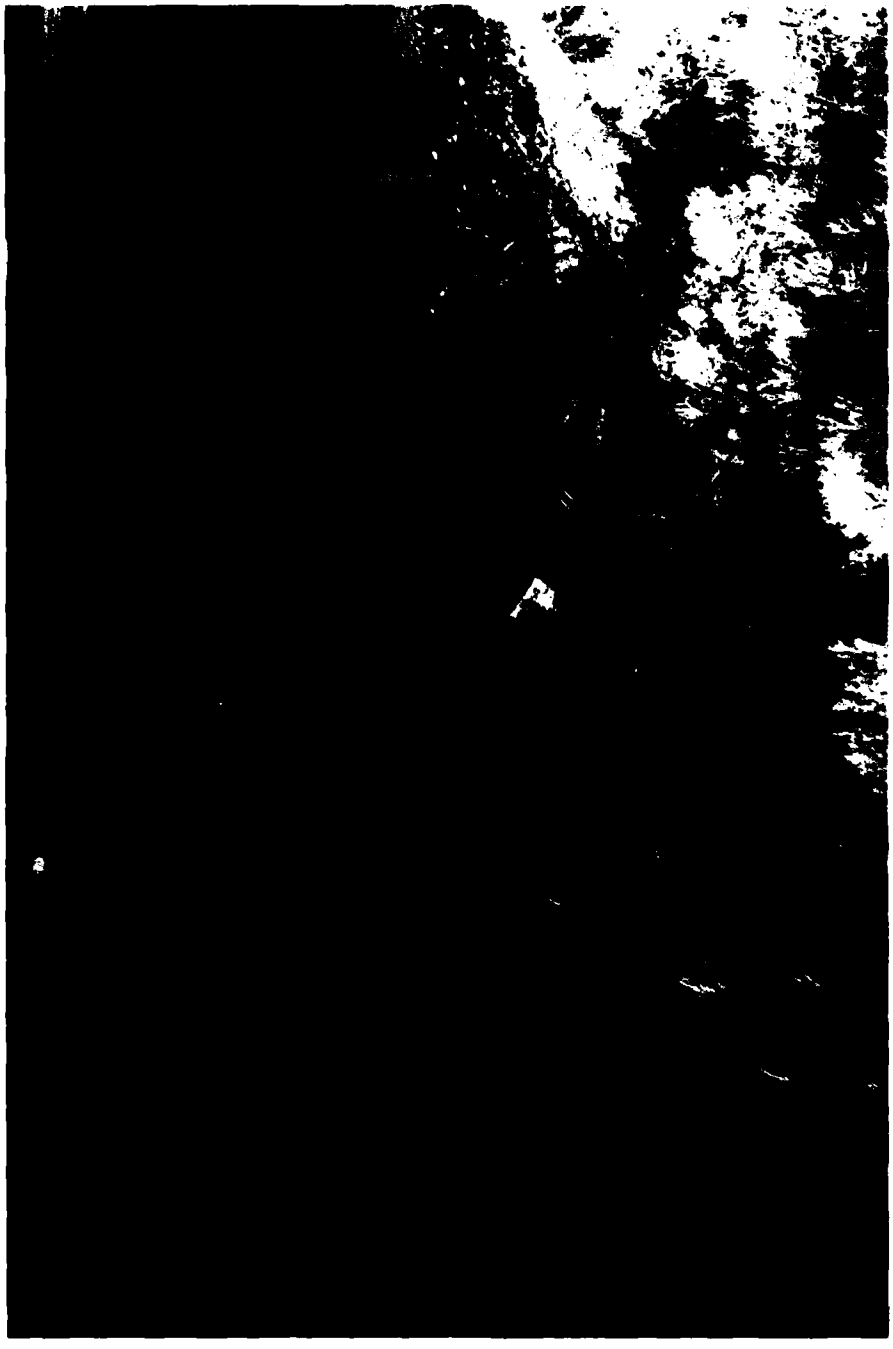
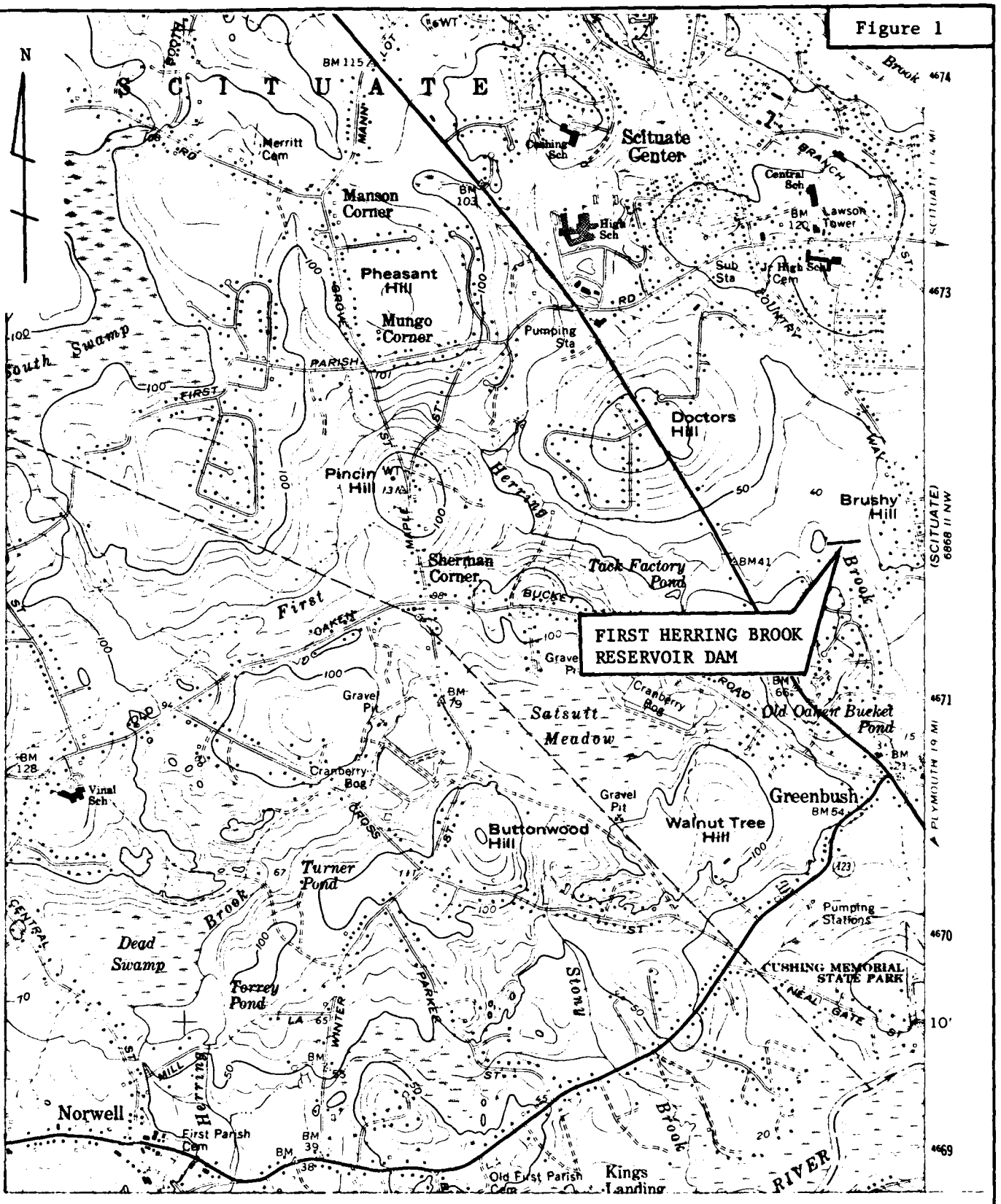
APPENDIXES



OVERVIEW PHOTO

U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM , MASSACHUSETTS ASEC CORP. CONSULTING ENGINEERS BOSTON , MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS	FIRST HERRING BROOK RES. DAM TR. TO NORTH RIVER SCITUATE, MASSACHUSETTS MA 00478 DECEMBER 10, 1980

Figure 1



LOCATION PLAN

FIRST HERRING BROOK RESERVOIR DAM
SCITUATE, MASSACHUSETTS
SCALE 1:25000

ASEC CORPORATION

COHASSET QUADRANGLE 1974

NATIONAL DAM INSPECTION PROGRAM

PHASE 1 INSPECTION REPORT

PROJECT INFORMATION

SECTION 1

1.1 GENERAL

a. AUTHORITY

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. ASEC Corporation has been retained by the New England Division to inspect and report on selected dams in the state of Massachusetts. Authorization and notice to proceed were issued to ASEC Corporation under a letter of December 8, 1980, from William E. Hodgson, Colonel, Corps of Engineers. Contract No. DACW33-81-C-0023 has been assigned by the Corps of Engineers for this work.

b. PURPOSE OF INSPECTION

The purposes of the program are to:

I. Perform technical inspection and evaluation of non-federal dams to identify conditions requiring correction in a timely manner by non-federal interests.

II. Encourage and prepare the States to quickly intitiate effective dam inspection programs for non-federal dams.

III. To update, verify and complete the National Inventory of Dams.

1.2 DESCRIPTION OF PROJECT

a. LOCATION

The dam is located upstream of Old Oaken Bucket Pond, on First Herring Brook, in the town of Scituate, Massachusetts, between State Route 3A and Country Way. First Herring Brook is a tributary to the North River located about 1 1/4 mi. downstream of the dam. The dam is shown on the Cohasset Quadrangle Map having coordinates latitude 42°-10.4' and longitude 70°-45.2' (See Figure 1).

b. DESCRIPTION OF DAM AND APPURTENANT STRUCTURES

The dam consists of an earth embankment with a concrete core wall. The embankment has a top width of 20 feet, a maximum height of 21.5 feet, upstream and downstream slopes of 2 horizontal to 1 vertical. The upstream slope is protected with rip-rap and the downstream slope is grass covered. Drawings indicate that the core wall is 15 inches wide and extends about 5 feet into the foundation and to within 1 foot of the crest of the dam. The overall length of the dam is 700 feet, including a 42 foot long concrete overflow spillway located near the center of the dam. A 3 foot wide concrete fish ladder is located about 35 feet to the left of the spillway. The outlet works, located approximately 20 feet to the right of the spillway consists of a 12 inch ductile iron low level outlet through the dam and core wall controlled by a manually operated downstream butterfly valve. Drawings indicate

an 8 inch diameter drain was to be placed behind the concrete core wall and to exit adjacent to the right and left spillway wingwalls. This appurtenance was not found during the field inspection of the dam.

c. SIZE CLASSIFICATION - "Small"

According to the Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams, a dam is classified as "Small" in size if the height is between 25 and 40 feet, or the dam impounds between 50 and 1000 acre-feet. The dam has a maximum height of 21.5 feet and a maximum storage capacity of 950 acre-feet. Therefore the dam is classified as small in size based on storage capacity.

d. HAZARD CLASSIFICATION - "High"

Based on the Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams, the Hazard Classification for the dam is "High". The dam is classified as a "High" hazard potential structure because it is located in a predominantly suburban area where failure may damage homes (about 30), two roads (Country Way and Driftway) and lead to the loss of more than a few lives. Post-failure flooding will be 1 to 7 feet above pre-failure flooding for the homes in question, depending upon their location. See Appendix D for failure analysis.

e. OWNERSHIP

Former Owner : None

Present Owner : Town of Scituate
c/o Board of Selectmen
Scituate Town Hall
600 Chief Justice Cushing Way
Scituate, MA 02066
(617) 545-6700

f. OPERATOR

Mr. William Jenkins, Superintendent
Scituate Water Department
4 Old Oaken Bucket Road
Greenbush, MA 02040
(617) 545-0033

g. PURPOSE OF DAM

The dam impounds First Herring Brook Reservoir, a storage reservoir for public water supply for the Town of Scituate.

h. DESIGN AND CONSTRUCTION HISTORY

The dam was designed in 1967 by Whitman and Howard Inc. Construction of the dam took place in 1969. The general contractor for the dam is unknown. Design plans exist and are included in Appendix B. No "As-built Plans" are known to exist for this dam. No post-construction changes have been made to the dam.

i. NORMAL OPERATIONAL PROCEDURES

The 12 inch low level outlet is opened or closed by means of the butterfly valve at the downstream slope of the dam as required to keep Old Oaken Bucket Pond at a constant elevation.

1.3 PERTINENT DATA

a. DRAINAGE AREA

The drainage area consists of 4.4 square miles of lightly developed land, mostly wooded with numerous hills rising to about 150 feet above mean sea level. See Watershed Map in Appendix D.

b. DISCHARGE AT DAMSITE

The discharge at the damsite is over a 42 foot wide broad-crested concrete spillway and a 3 foot wide concrete fish ladder. Outlet works consist of a 12 inch diameter ductile iron pipe through the dam controlled by a downstream butterfly valve.

NGVD = National Geodetic Vertical Datum

1.	Outlet Works (conduit) Size:	12 inch diameter
	Invert Elevation:	27.2 at Inlet
	Discharge Capacity:	12 cfs @ EL.40 ft.NGVD
2.	Maximum Known Flood at Damsite:	200 cfs (estimated)
3.	Ungated Spillway Capacity at Top of Dam Elevation:	2,300 cfs 46.5 ft. NGVD
4.	Ungated Spillway Capacity at Test Flood Elevation Elevation:	500 cfs 42.5 ft. NGVD
5.	Gated Spillway Capacity at Normal Pool Elevation Elevation:	N/A
6.	Gated Spillway Capacity at Test Flood Elevation Elevation:	N/A
7.	Total Spillway Capacity at Test Flood Elevation Elevation:	500 cfs 42.5 ft. NGVD
8.	Total Project Discharge at Top of Dam Elevation:	2,300 cfs 46.5 ft. NGVD
9.	Total Project Discharge at Test Flood Elevation Elevation:	500 cfs 42.5 ft. NGVD

c. ELEVATION - Feet above National Geodetic Vertical Datum

1.	Streambed at toe of dam	25.0
2.	Bottom of cutoff	24.0
3.	Maximum Tailwater	Unknown
4.	Normal Pool	40.5
5.	Full Flood Control Pool	N/A
6.	Spillway Crest	40.0
7.	Design Surcharge-Original Design	Unknown
8.	Top of Dam	46.5
9.	Test Flood Surcharge	42.5

d. RESERVOIR - Length in Feet

1.	Normal Pool	2,300
2.	Flood Control Pool	N/A
3.	Spillway Crest Pool	2,300
4.	Top of Dam	2,350
5.	Test Flood Pool	2,300

e. STORAGE - Acre-feet

1.	Normal Pool	600
2.	Flood Control Pool	N/A
3.	Spillway Crest Pool	500
4.	Top of Dam	950
5.	Test Flood Pool	700

f.	RESERVOIR SURFACE - Acres	
1.	Normal Pool	60
2.	Flood Control Pool	N/A
3.	Spillway Crest	60
4.	Test Flood Pool	60
5.	Top of Dam	60
g.	DAM	
1.	Type	Earth embankment with concrete core wall
2.	Length	700 feet
3.	Height	21.5 feet
4.	Top Width	20 feet
5.	Side Slopes	2 Horizontal to 1 Vertical (Upstream & Downstream)
6.	Zoning	Unknown
7.	Impervious Core	15 inch wide concrete core wall *
8.	Cutoff	Core wall extends about 5 feet into foundation *
9.	Grout curtain	None
10.	Other	Underdrain downstream of core wall and on sides of taining wall *
h.	DIVERSION AND REGULATING TUNNEL	N/A

* Indicated on design drawings, not observed in field inspection.

i.	Spillway	
1.	Type	Broadcrested concrete overflow
2.	Length of Weir	42 feet
3.	Crest Elevation	40.0 feet (NGVD)
4.	Gates	N/A
5.	Upstream channel	None
6.	Downstream channel	Not well defined unpaved
7.	General	
j.	REGULATING OUTLETS	
1.	Invert	27.2 feet (NGVD) inlet 26.8 feet (NGVD) outlet
2.	Size	12 inch diameter
3.	Description	Ductile iron pipe through dam and core wall. Controlled by downstream butterfly valve.
4.	Control mechanism	Manually operated butterfly valve.
5.	Capacity	12 cfs @ El.40 ft.NGVD

ENGINEERING DATA

SECTION 2

2.1 DESIGN DATA

Design data consisted of the original plans for the dam, dated December, 1967, by Whitman and Howard Inc. These plans are included in Appendix B. These documents contain the principal information regarding the design reviewed in the preparation of this report. Design computations for this dam were unavailable.

2.2 CONSTRUCTION DATA

No construction data was available for review. It is reported that the dam was constructed by the Town of Scituate in 1969. The name of the contractor is not known.

2.3 OPERATIONAL DATA

Daily records of the reservoir level are maintained by the Scituate Water Department. The reservoir is normally at or below spillway level.

2.4 EVALUATION OF DATA

a. AVAILABILITY

Existing data was provided by the Town of Scituate Department of Public Works. A list of available reference material and their location is given in Appendix B.

b. ADEQUACY

The engineering data reviewed did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed

from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history, hydraulic and hydrologic calculations and sound engineering judgment.

c. VALIDITY

Field inspections and surveys indicate that the observed portions of the dam were constructed substantially as shown on the plans.

VISUAL INSPECTION

SECTION 3

3.1 FINDINGS

a. GENERAL

The visual inspection of the dam was conducted on December 8, 1980. At the time of inspection, the water level of the dam was approximately 6.5 feet below spillway level. The general condition of the dam at the time of inspection was fair.

The dam is an earth embankment with a concrete overflow spillway located near the center of the dam and a 3 foot wide concrete fish ladder located about 35 feet to the left of this spillway (Overview Photo). The outlet works consists of a 12" ductile iron pipe through the dam which is controlled by a butterfly valve located in a manhole in the downstream slope of the dam.

b. DAM

The dam consists of an earth embankment with upstream and downstream slopes of 2H:1V. The plans indicate the dam has a concrete core wall extending to within one foot of the crest of the dam. The core wall was not observed during the field visit. The crest of the embankment is grass-covered with brush existing along the upstream slope. A pedestrian path, almost bare of vegetation, has been worn along the entire length of the crest. The upstream slope is covered with rip-rap, about 12 to 22 inches in size, from an elevation about 1 foot below the crest to

below the water level in the reservoir at the time of inspection. In some areas holes exist through the rip-rap and erosion has occurred near the crest. Brush was growing between the rip-rap pieces near the crest of the dam.

The downstream slope is covered with grass, weeds and small brush near the spillway wingwalls. There is one area (shown on Figure 2 page B-1), about 80 feet by 25 feet in size, which is wet and soft but with no visible discharge of seepage water. Several animal burrows up to 12 in. in diameter and 8 in. deep were observed near the toe of the dam approximately 100 feet west of the right spillway training wall.

Erosion has occurred on the downstream slopes adjacent to the spillway wingwalls (Photo #1). Seepage is evident at the end of the right spillway wingwall (Photo #2). The flow from this area could not be estimated. There is some reddish staining in the area but the flow is clear with no visible evidence of fines. There was a wet area evident at the end of the left spillway wingwall. The contacts between the downstream slope and abutments appear to be in good condition.

c. APPURTENANT STRUCTURES

The spillway has a broadcrested concrete weir and concrete training walls which are in fair condition (Photo #3 & #8). The crest of the weir has a spalled area about 3 feet in diameter and 1 -2 inches deep. No reinforcing is exposed in this spalled area (Photo #4). The right and left wing walls are cracked at the weir face, the cracks are vertical and diagonal (Photo #5) with displacement apparent at the left wingwall. Staining was noted on

the left training wall diagonal crack (Photo #6).

The concrete fish ladder was in fair condition. Vertical cracks, apparently construction joints, were observed in both fish ladder sidewalls at the crest of the dam, no displacement was evident.

A manhole exists on the downstream face of the dam on the right side of the spillway. This manhole contains the butterfly valve used to regulate the flow in the 12 inch ductile iron low level outlet pipe. The valve was reported to be operable. There is no shutoff on the upstream end of this low level outlet.

d. RESERVOIR AREA

No evidence of significant sedimentation in the reservoir was observed.

e. DOWNSTREAM CHANNEL

The downstream channel is not well defined and meanders downstream of the dam (Photo #7). The channel bottom is covered with grass, brush and boulders.

3.2 EVALUATION

On the basis of the visual inspection, the dam is judged to be in fair condition.

The soft, wet area adjacent to the downstream toe suggests that the line of seepage through the dam may exit at or near the toe of the slope, a condition which could lead to a piping failure of the embankment if the embankment soils or foundation soils are susceptible to piping. No observation wells or piezometers, which provide a measurement of the phreatic surface in the dam, were

located in the dam or foundation soils. In addition, the seepage adjacent to the spillway training walls could cause internal erosion of the dam.

The plans indicate that this seepage may be the discharge from 8 inch diameter drains shown on the drawings to be behind the concrete training walls on both sides of the spillway. The drain pipes were not visible during the field visit.

The worn pedestrian path on the crest of the dam makes the crest more susceptible to erosion in the event the dam should be overtopped.

Animal burrows on the downstream slope could lead to seepage and piping if not properly backfilled with select materials.

The slight irregularity in the rip-rap and erosion on the upstream slopes indicate some movement of the rip-rap has occurred, probably due to wave and freezing action. However, the rip-rap appears to provide adequate erosion protection and only minor repairs appear needed at this time.

The poorly defined discharge channel downstream could result in erosion of the downstream toe of the dam during periods of significant discharge over the spillway.

Cracks observed in spillway training walls and fish ladder sidewalls can lead to deterioration of wall reinforcing, compromising the strength of the structure. Cracks can lead to susceptibility to frost action. Vertical cracking appears to be along construction joints; it is unknown whether waterstops have

been provided at all of these joints, however, the absence of efflorescence along these cracks indicate that these have been provided. Diagonal cracks in the training wall appear to indicate a differential settlement of wall and weir.

The spalled area on the crest of the spillway weir creates a ponding area at times of no flow, subjecting this area to freeze thaw cycles in winter. Spalling lessens the cover over existing reinforcing. The spalling appears to be the result of vandalism rather than natural causes.

There is no shutoff at the upstream end of the low level outlet pipe. Should a leak or fracture of the pipe occur upstream of the existing valve - a portion of the line always under pressure - internal erosion of the dam along the line of this pipe is possible. Repair of the upstream portion of this pipe in cases of leaking or fracture would also be extremely difficult.

OPERATIONAL AND MAINTENANCE PROCEDURES

SECTION 4

4.1 OPERATIONAL PROCEDURES

a. GENERAL

The dam is used primarily to maintain a constant water level in Old Oaken Bucket pond, a town surface water supply directly downstream of this dam. The low level outlet for the reservoir is opened and closed by means of the 12" butterfly valve at the dam to accomplish this.

The surface elevation of the reservoir is monitored daily from a concrete headwall located on State Route 3A. The dam itself cannot be viewed from this location.

b. DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no formal warning system in effect.

4.2 MAINTENANCE PROCEDURES

a. GENERAL

The grass on the downstream slope of the dam is mowed approximately 3 - 4 times per year by the public grounds division of the Scituate Department of Public Works. There are no formal inspection procedures. The dam is not patrolled.

b. OPERATING FACILITIES

The low level intake and butterfly valve are the operational portions of this dam requiring maintenance. No formal maintenance procedures exist for these items.

4.3 EVALUATION

Present operational procedures should be modified to include establishment of a formal downstream warning system. Procedures should be established for monitoring the dam during periods of exceptionally heavy rainfall and notifying downstream authorities in the event of an emergency.

A formal written maintenance program for the dam should be prepared and implemented.

The dam should be subject to annual technical inspections by a qualified registered engineer.

EVALUATION OF HYDRAULIC/HYDROLOGIC FEATURES

SECTION 5

5.1 GENERAL

First Herring Brook Reservoir is the first reservoir in a series of two reservoirs. It is located upstream of Old Oaken Bucket Pond. The dam has a tributary watershed of 4.4 square miles. The watershed consists of rolling hills and two relatively large wetland areas. The reservoir is surrounded by areas of sparse suburban development, with the State Route 3A embankment forming the upstream end of the reservoir.

The dam crest is even and at approximately El. 46.5 NGVD. The spillway crest is at EL. 40.0 NGVD. The ungated spillway capacity with the pool at the top of dam is 2,300 cfs. No flashboards are presently used at this dam.

5.2 DESIGN DATA

This dam was designed by Whitman and Howard Engineers in 1967 amd was constructed in 1969. Plans titled: "Proposed Reservoir and Dam, Scituate, MA" were obtained from the town. Hydrologic/hydraulic data were not available.

5.3 EXPERIENCE DATA

Town of Scituate Water Department records indicate the highest reservoir elevation to be 11 inches over the spillway crest or El. 40.9 NGVD on February 27,1979. Entering the spillway rating curve (Graph #1 in Appendix D) this yields a discharge of 110 cfs. High water marks observed on the spillway wingwalls indicate water levels have reached approximately 16 inches above the spillway which yields a discharge of approximately 200 cfs.

5.4 TEST FLOOD ANALYSIS

Based on the Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams, the size of the dam is small. The dam has approximately 950 acre-feet of storage at the top of dam (El. 46.5± NGVD). Based on dam failure analysis and the above guidelines the dam is classified as "High" hazard potential.

Based on the Corps of Engineers' guidelines, the Test Flood should be in the range of 1/2 of the Probable Maximum Flood (PMF) to PMF. Since the height of the dam is relatively low for the dam's size classification, a 1/2 PMF or a flood approaching that magnitiude was used for the test flood. It is considered that the 500 year peak discharge as computed by the USGS Regional Equations for Eastern Massachusetts will yield a reasonable estimate for a large magnitude storm approaching the 1/2 PMF. The resultant peak inflow for the 500 year event using the USGS Regional Equations is about 600 cfs. This peak reservoir inflow was routed through the reservoir using the Corps of Engineers' "Surcharge Routing Alternative" and resulted in an attenuated peak test flood discharge of about 500 cfs at the spillway. For the purpose of surcharge storage routing calculations, the initial reservoir level was assumed to be at the spillway crest. The spillway passes 100% of the test flood with a resultant stage of 2.5 feet above the spillway crest, El. 42.5 NGVD. The spillway capacity is judged to be adequate.

5.5 DAM FAILURE ANALYSIS

A dam failure analysis was made using the "Rule of Thumb Guidance" provided by the Corps of Engineers. Failure was assumed

with water at the top of dam, approximately El. 46.5 NGVD. The prime impact areas lie around the perimeter of Old Oaken Bucket Pond and from the outlet of Old Oaken Bucket Pond downstream to the area where the First Herring Brook floodplain expands out into the extensive North River salt marsh system.

Around the perimeter of Old Oaken Bucket Pond, 17 houses will receive from 1 - 3 feet of flooding, 4 houses will receive from 3 - 4 feet of flooding, a Town of Scituate pump station will receive 5 feet of flooding and 3 commercial structures will receive 1 - 3 feet of flooding. From the outlet of Old Oaken Bucket Pond downstream to the North River saltmarsh system 2 houses and 1 commercial structure will receive from 3 - 7 feet of flooding and 3 houses will receive from 1 - 3 feet of flooding.

The dam is classified as "High" hazard potential. A dam failure could result in the loss of more than a few lives and excessive economic losses in the area downstream of the dam.

Table 1 summarizes pre- and post-failure flooding effects. Appendix D includes a map of the inundated area resulting from this dam failure analysis, a narrative of potential flooding, and the dam breach calculations.

The table below summarizes the downstream effects of failure of First Herring Brook Reservoir Dam:

Location No. (see map)	Distance D/S of Dam (ft)	Number of Structures	Level Above Stream (ft)	Flow (CFS) Stage (Ft. above Stream) Before Failure	Flow (CFS) Stage (Ft. above Stream) After Failure	Comments
1	1150	5 houses	7-9	2280 2.6	16,380 6.1	
2	1200	1 house	4			Some damage to 1 house Little danger of loss of life
3	2640	7 houses 3 houses	7 5	2280 5.2	15,314 8.0	Some damage to 10 houses Little danger of loss of life
4	2640-3600	7 houses 4 houses	5-7 4-5	2280 5.0	14,275 8.0	Some damage to 11 houses
	3670	pump station	3			Major damage to pump station
	3670	2 commercial buildings	5-7			Minor damage to 2 stores
	3670	1 professional building	5			Some damage to professional building Some danger of loss of life
Country Way Rd.	3670	road	3			Probably washed out
Driftway	4457	road	4	2280	13,490	Probably washedout
	3900	1 commercial building	9-12	6.6	14.8	Major damage to commercial building Some danger of loss of life
5	4457-5300	3 houses	12-14	2280 7.5	12,100 15.0	Minor damage to 3 houses Little danger of loss of life
		2 houses	8-12			Major damage to 2 houses Some danger of loss of life
Salt Marsh	5500-					Flood wave completely attenuated No damage to property No risk of loss of life

Table 1 - Summary of Downstream Flooding

EVALUATION OF STRUCTURAL STABILITY

SECTION 6

6.1 VISUAL OBSERVATIONS

The visual inspection did not disclose any indications of present structural instability. The long term performance of the dam could be affected by the continued seepage along the downstream toe of the dam to the right of the spillway and the lack of an upstream shutoff for the low level outlet pipe.

6.2 DESIGN AND CONSTRUCTION DATA

The design and construction data reviewed consists of a set of plans by Whitman & Howard Inc. entitled "Proposed Dam and Reservoir, Scituate, Mass." (4 sheets) dated December 1967. Record drawings indicate that the dam is constructed of either "compacted glacial till or pervious fill". There is a concrete core wall 15 in. wide shown extending about 5 feet into the foundation and to within one foot of the crest of the dam. The drawings indicate an 8 in. diameter drain was specified to be placed behind the concrete core wall and to exit adjacent to the right and left spillway wingwalls. It is not possible to determine on the basis of the visual inspection whether or not the dam was actually constructed as shown on the record plans.

6.3 POST CONSTRUCTION CHANGES

No post construction changes have been made on the dam since it was built in 1969. In general, the watershed for the reservoir has become more urbanized since construction.

6.4 SEISMIC STABILITY

The dam is located in Seismic Zone 2, and in accordance with Corps of Engineers' guidelines does not warrant further seismic analysis at this time.

ASSESSMENT, RECOMMENDATIONS, & REMEDIAL MEASURES

SECTION 7

7.1 DAM ASSESSMENT

a. CONDITION

On the basis of the visual inspection, the dam is judged to be in fair condition. The following conditions will effect the long term performance of the dam:

1. The soft wet area at the downstream toe of the dam suggests that the line of seepage through the dam exits near the toe, a condition which could lead to piping failure if the embankment or foundation soils are susceptible to piping.

2. The seepage adjacent to the right and left wingwalls could lead to piping around the spillway structure if it is not the discharge from the 8 inch diameter pipes shown on the design drawings.

3. The sparse vegetation in the pedestrian path on the crest of the dam makes the crest more susceptible to erosion in the event the dam should be overtopped.

4. The animal burrows on the downstream slope could lead to seepage and piping problems if they are not properly backfilled.

5. Continued erosion of the upstream face near the crest and adjacent to the spillway training walls could result in possible breaching if the dam were overtopped.

6. Cracked and spalled areas of concrete on the weir and training walls may increase the concrete's susceptibility to frost action and may compromise the strength of the walls.

b. ADEQUACY OF INFORMATION

The results of the visual inspection and the information available from record drawings was adequate for performing a Phase 1 Inspection.

c. URGENCY

The recommendations presented in Sections 7.2 and 7.3 should be carried out within one year of receipt of this report by the owner.

7.2 RECOMMENDATIONS

The following recommendations should be carried out under the direction of a qualified, registered engineer.

1. Specify and oversee procedures for patching cracks along spillway training walls and the spalled area at the spillway crest.

2. Specify and oversee procedures for filling animal burrows on the downstream slope with proper backfill material.

3. Investigate the cause of the soft, wet area at the downstream toe of the slope, design remedial measures and oversee construction of the remedial measures.

4. Investigate the cause of seepage at the base of the right and left spillway training walls and design remedial measures as required.

5. Provide upstream control for the 12" diameter low level outlet pipe.

6. Excavate the discharge channel and provide slope protection around outlet and spillway.

7. Repair rip-rap "holes" in upstream slope protection.

8. Investigate displacement of the left spillway sidewall at the vertical crack.

9. Design erosion protection for the upstream edge of the crest and adjacent to the spillway training walls and oversee construction of the erosion protection.

7.3 REMEDIAL MEASURES

a. OPERATION AND MAINTENANCE PROCEDURES

1. The dam and appurtenant structures should be visually inspected once a month.

2. A technical inspection of the dam should be performed once a year by a qualified, registered engineer.

3. Institute a formal downstream warning system to include monitoring of the dam during extremely heavy rains, and establish a downstream warning system in case of emergency at the dam.

4. Remove brush from the slopes of the dam.

5. Establish grass cover on bare areas of dam crest and downstream slope.

6. Prepare and implement a formal written maintenance program.

7.4 ALTERNATIVES

There are no practical alternatives to the above recommendations.

APPENDIX A

INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST
PARTY ORGANIZATION

PROJECT FIRST HERRING BROOK RESERVOIR DAM

DATE DECEMBER 8,1980
TIME 12:15 PM
WEATHER CLEAR,COLD
W.S.EL. 33.5 U.S.
25.0 D.S.

PARTY:

1. John F. Modzelewski P.E. ASEC Corporation - Civil/Structural
2. Richard M. Baker Vollmer Associates Inc. - Hydrologist
3. Richard F. Murdock P.E. Geotechnical Engineers Inc.- Geotechnical
4. Richard W. Turnbull Geotechnical Engineers Inc.- Geotechnical

PROJECT FEATURE	INSPECTED BY
1. Dam Embankment	GEI
2. Dike Embankment	None observed
3. Outlet Works - Intake Channel Intake Structure	None observed
4. Outlet Works - Transition & Conduit	None observed
5. Outlet Works - Control Tower	None observed
6. Outlet Works - Transition & Conduit	None observed
7. Outlet Works - Outlet Structure & Outlet Channel	None observed
8. Outlet Works - Spillway Weir, Approach & Discharge Channels	ASEC, GEI
8a. Outlet Works - Fish Ladder	ASEC
9. Outlet Works - Service Bridge	None observed

PERIODIC INSPECTION CHECKLIST

PROJECT FIRST HERRING BROOK RESERVOIR DAM DATE Dec. 8, 1980

PROJECT FEATURE see below NAME JFM, RFM, RWT,

DISCIPLINE Civil Engineer, Geotechnical Engineer NAME

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	46.5 ft.
Current Pool Elevation	33.5 ft.
Maximum Impoundment to Date	11 " above spillway level
Surface Cracks	None observed.
Pavement Condition	No pavement.
Movement or Settlement of Crest	None observed.
Lateral Movement	None observed.
Vertical Alignment	Good.
Horizontal Alignment	Good.
Condition at Abutment and at Concrete Structures	Moderate erosion adjacent to upstream and downstream sides of left and right spillway wingwalls and fish ladder walls.
Indications of Movement of Structural Items on Slopes	Spillway wingwalls cracked top to bottom along centerline of crest.
Trespassing on Slopes	One-ft-wide footpath along centerline of crest.
Sloughing or Erosion of Slopes or Abutments	Minor gullying and sloughing along upstream and downstream trees, particularly adjacent to the spillway wingwalls and fish ladder walls.
Rock Slope Protection - Riprap Failures	Local riprap windows e.g. top of upstream slope between ladder and spillway; also the displacement of riprap along the right side of the spillway has led to gullying and sloughing of upstream face.
Unusual Movement or Cracking at or Near Toe	None observed.
Unusual Embankment or Downstream Seepage	Seepage observed at downstream end of right spillway wingwall; clear and free of sediment; wet area at base of slope from Sta 3+20 to 4+08.
Piping or Boils	None observed.
Foundation Drainage Features	None observed.
Toe Drains	12"-diameter drainage pipe at toe of downstream slope (behived to connect with manhole ∿ at Sta 3+95.
Instrumentation System	None observed.
Vegetation	Crest and downstream slope covered with grass and very occasional weeds; minor brush growing between boulder riprap.

PERIODIC INSPECTION CHECKLIST

PROJECT FIRST HERRING BROOK RESERVOIR DAM DATE Dec. 8, 1980

PROJECT FEATURE see below NAME --

DISCIPLINE -- NAME

AREA EVALUATED	CONDITION
DIKE EMBANKMENT	None.
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	
Pavement Condition	
Movement or Settlement of Crest	
Lateral Movement	
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	
Indications of Movement of Structural Items on Slopes	
Trespassing on Slopes	
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection - Riprap Failures	
Unusual Movement or Cracking at or Near Toes	
Unusual Embankment or Downstream Seepage	
Piping or Boils	
Foundation Drainage Features	
Toe Drains	
Instrumentation System	
Vegetation	

PERIODIC INSPECTION CHECKLIST

PROJECT FIRST HERRING BROOK RESERVOIR DAM DATE Dec. 8, 1980

PROJECT FEATURE see below NAME --

DISCIPLINE -- NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	None.
a. Approach Channel	
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	None.
Condition of Concrete	
Stop Logs and Slots	

PERIODIC INSPECTION CHECKLIST

PROJECT FIRST HERRING BROOK RESERVOIR DAM DATE Dec. 8, 1980

PROJECT FEATURE see below NAME --

DISCIPLINE -- NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	None
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

PERIODIC INSPECTION CHECKLIST

PROJECT FIRST HERRING BROOK RESERVOIR DAM DATE Dec. 8, 1980

PROJECT FEATURE see below NAME --

DISCIPLINE -- NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	None
General Condition of Concrete	
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECKLIST

PROJECT FIRST HERRING BROOK RESERVOIR DAM DATE Dec. 8, 1980

PROJECT FEATURE see below NAME --

DISCIPLINE -- NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	None
Rust or Staining	
Spalling	
Erosion or Cavitation	
Visible Reinforcing	
Any Seepage or Efflorescence	
Condition at Joints	
Drain holes	
Channel	
Loose Rock or Trees Overhanging Channel	
Condition of Discharge Channel	

PERIODIC INSPECTION CHECKLIST

PROJECT FIRST HERRING BROOK RESERVOIR DAM DATE Dec. 8, 1980

PROJECT FEATURE see below NAME JFM, RFM, RWT,

DISCIPLINE Civil Engineer, Geotechnical Engineer NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	Concrete wingwalls.
General Condition	Good, unobstructed.
Loose Rock Overhanging Channel	None.
Trees Overhanging Channel	None.
Floor of Approach Channel	Concrete preceded by cobble and boulder riprap; unobstructed.
b. Weir and Training Walls	
General Condition of Concrete	fair, vertical & diagonal cracks in walls near spillway crest, minor displacement along vertical crack left wall.
Rust or Staining	Minor staining at diagonal cracks near spillway crest
Spalling	Spalled area at crest of weir
Any Visible Reinforcing	None
Any Seepage or Efflorescence	Minor efflorescence near wall caps, downstream end of training walls, seepage at base of walls downstream ends.
Drain Holes	None observed.
c. Discharge Channel	Concrete floor into 4 ft of cobbles into natural stream and marsh area.
General Condition	Good, unobstructed.
Loose Rock Overhanging Channel	None.
Trees Overhanging Channel	None.
Floor of Channel	Scattered cobbles and minor debris, no major obstructions.
Other Obstructions	
Other Comments	

PERIODIC INSPECTION CHECKLIST

PROJECT FIRST HERRING BROOK RESERVOIR DAM DATE Dec. 8, 1980

PROJECT FEATURE SEE BELOW NAME JFM, RFM, RWT

DISCIPLINE Civil Engineer , Geotechnical Engineer NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - FISH LADDER	
a. Approach Channel	None
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Approach Channel	
b.	
General Condition of Concrete	fair, vertical cracks along apparent construction joints at dam crest.
Rust or Staining	None observed
Spalling	None observed
Any Visible Reinforcing	None observed
Any Seepage or Efflorescence	None observed
Drain Holes	None observed.
c. Discharge Channel	discharges into spillway weir discharge channel, see comments under Outlet Works - Spillway Weir, Approach and Discharge Channels
General Condition	
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Channel	
Other Obstructions	
Other Comments	

PERIODIC INSPECTION CHECKLIST

PROJECT FIRST HERRING BROOK RESERVOIR DAM DATE Dec. 8, 1980

PROJECT FEATURE see below NAME --

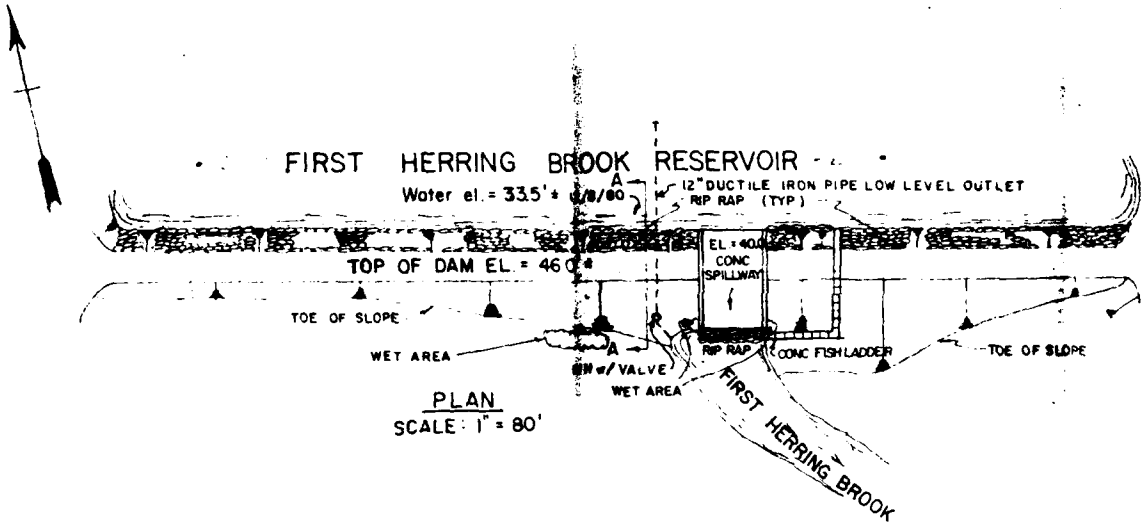
DISCIPLINE -- NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	
a. Super Structure	None
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Underside of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

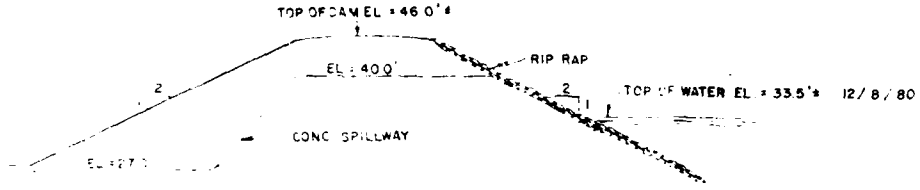
APPENDIX B

ENGINEERING DATA

FIGURE 2



PLAN
SCALE: 1" = 80'



SECTION A-A
NOT TO SCALE

NOTES
1) PLAN & SECTIONS TAKEN FROM PLAN ENTITLED "PROPOSED DAM & RESERVOIR SCITUATE, MASS." BY WHITMAN & HOWARD INC. DATED DEC. 1967
2) DATUM = NATIONAL GEODETIC VERTICAL DATUM

ASEC CORPORATION CONSULTING ENGINEERS BOSTON, MASS.	U.S. ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

FIRST HERRING BROOK RESERVOIR DAM

MASS. # 478

DRAWN	CHECKED	APPROVED	SCALE	DATE	PLATE
J.B.S.			AS NOTED	2-2-1981	F-1

LIST OF REFERENCES

Reference 1 is located at the Scituate Department of Public Works, 600 Chief Justice Cushing Way, Scituate, Massachusetts 02066. References 2 and 3 are located at the Department of Environmental Quality Engineering, Division of Waterways, 100 Nashua Street, Boston, Massachusetts 02114.

1. "Proposed Dam and Reservoir, Scituate, Massachusetts" Whitman & Howard Engineers & Architects, Boston, MA. December, 1967.

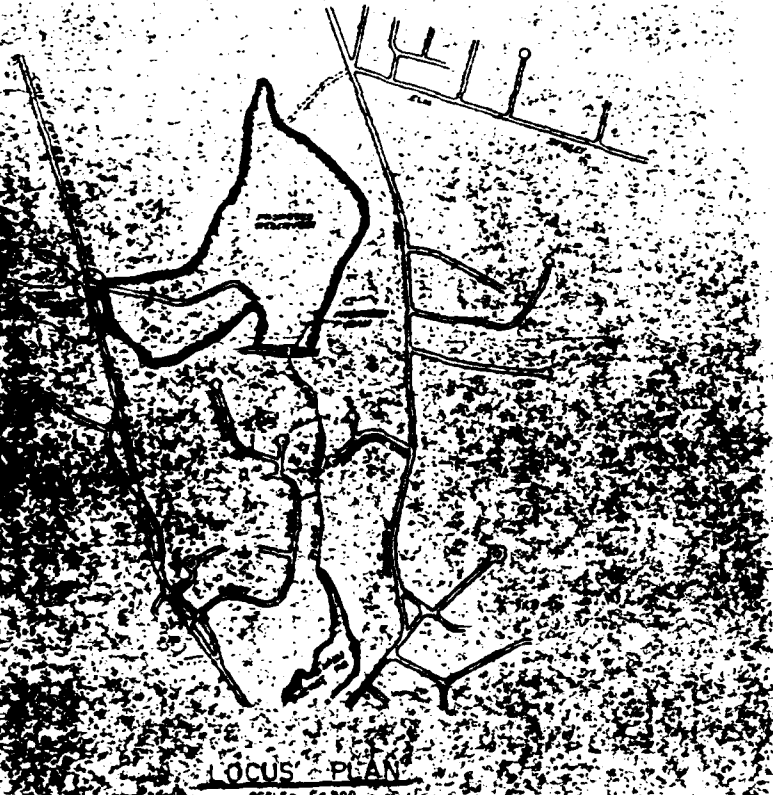
2. "Inspection Report-Dams and Reservoirs", Department of Environmental Quality Engineering, Boston, MA dated 4/13/'77.

3. "Inspection Report-Dams and Reservoirs", Department of Environmental Quality Engineering, Boston, MA dated 5/30/'74.

DAM AND RESERVOIR

SCITUATE MASS.

Whitman & Howard Inc., Engineers & Architects
89 Broad St., Boston, Mass.

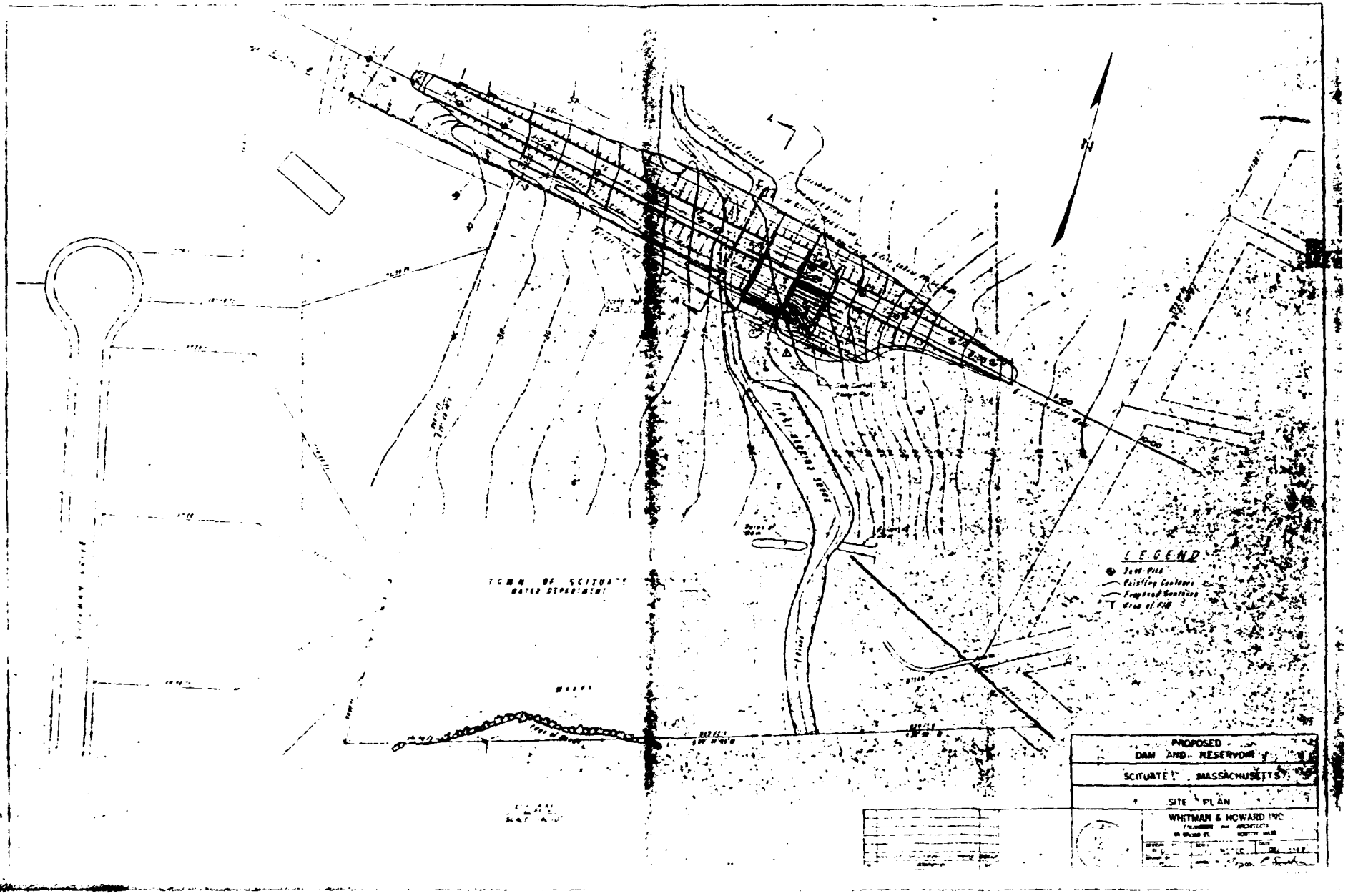


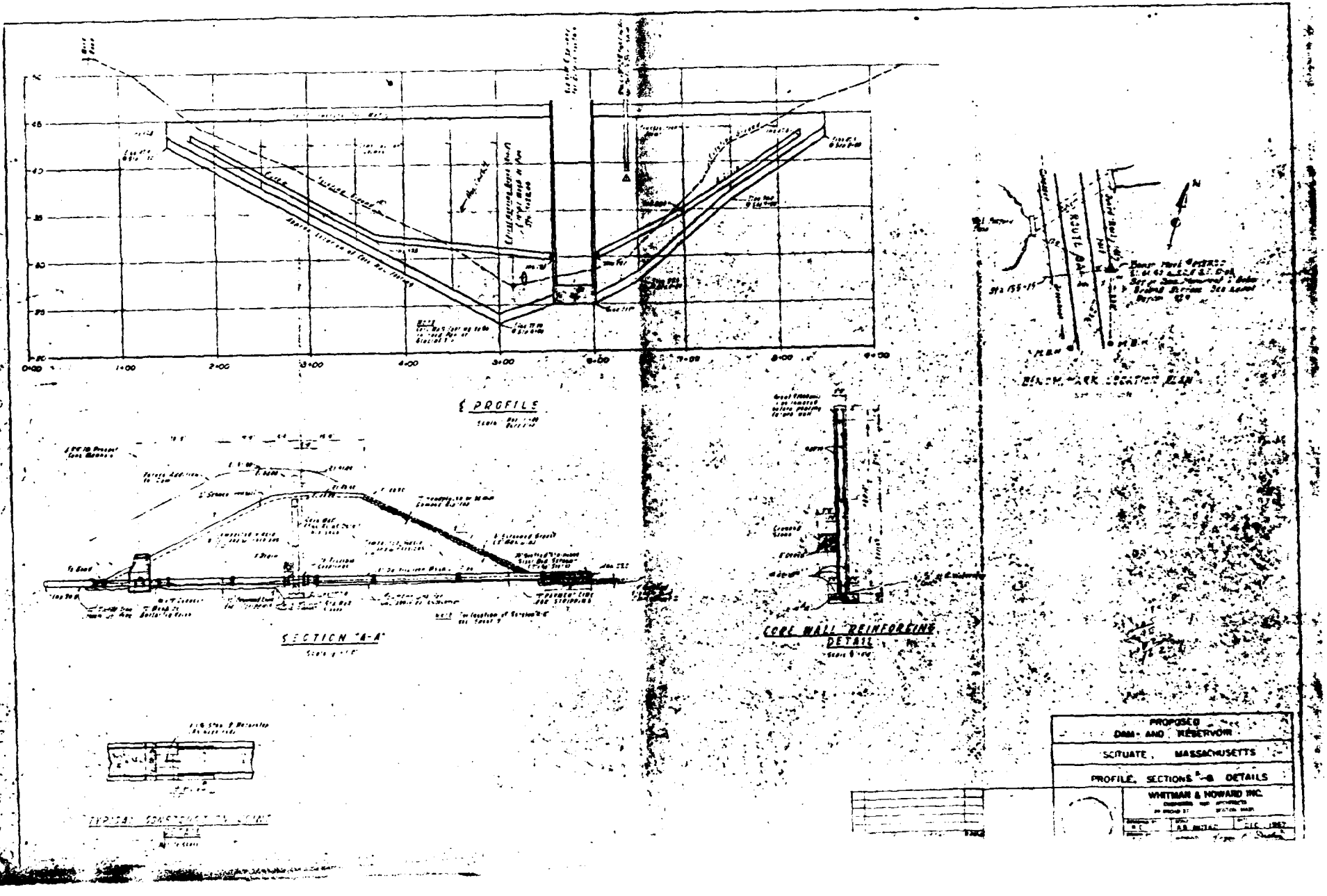
LOCUS PLAN

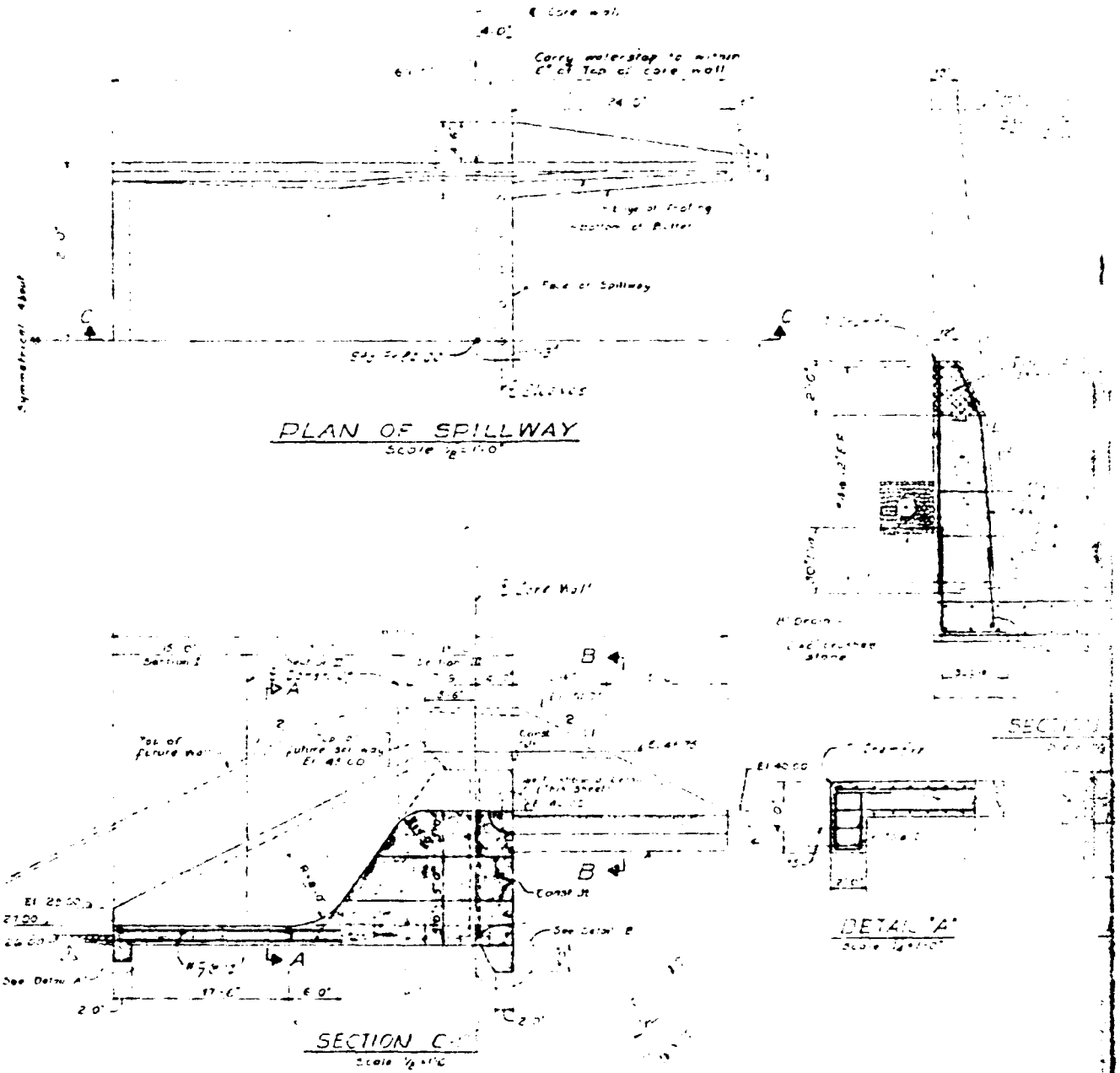
SCALE: 1"=500'

INDEX

SHEET OF 4 SHEETS


LEGEND
PROPOSED
DAM AND RESERVOIR
SCITUATE MASSACHUSETTS
SITE PLAN
WHITMAN & HOWARD INC

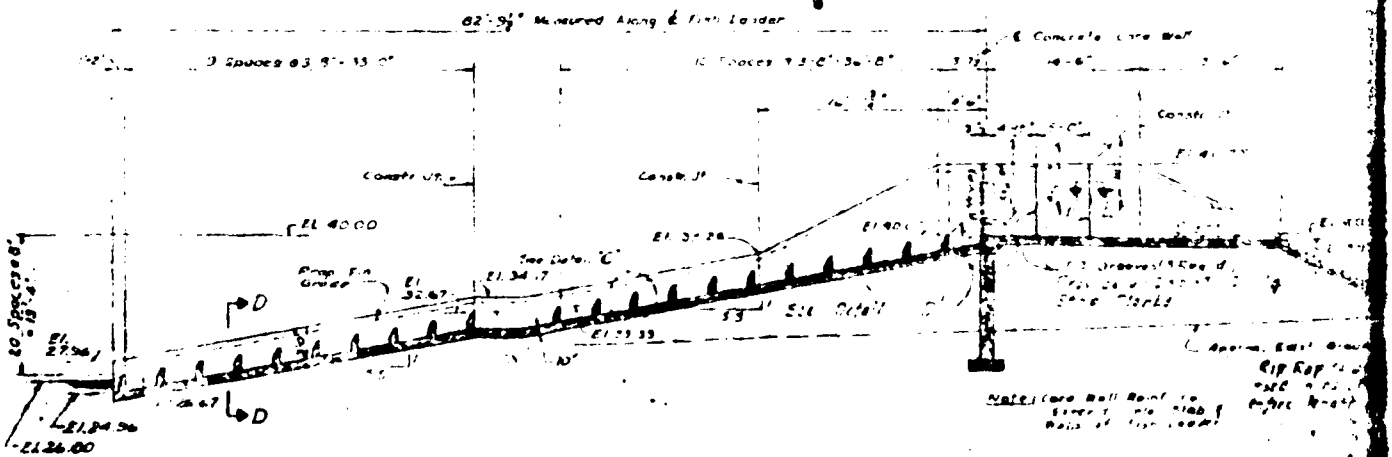

℄ PROFILE
SECTION "A-A"
CORE WALL REINFORCING DETAIL
BENCH MARK LOCATION PLAN
PROPOSED DAM AND RESERVOIR
SCITUATE, MASSACHUSETTS
PROFILE, SECTIONS A-B DETAILS
WHITMAN & HOWARD INC.



PLAN OF SPILLWAY
Scale 1/8" = 1'-0"

SECTION C-C
Scale 1/8" = 1'-0"

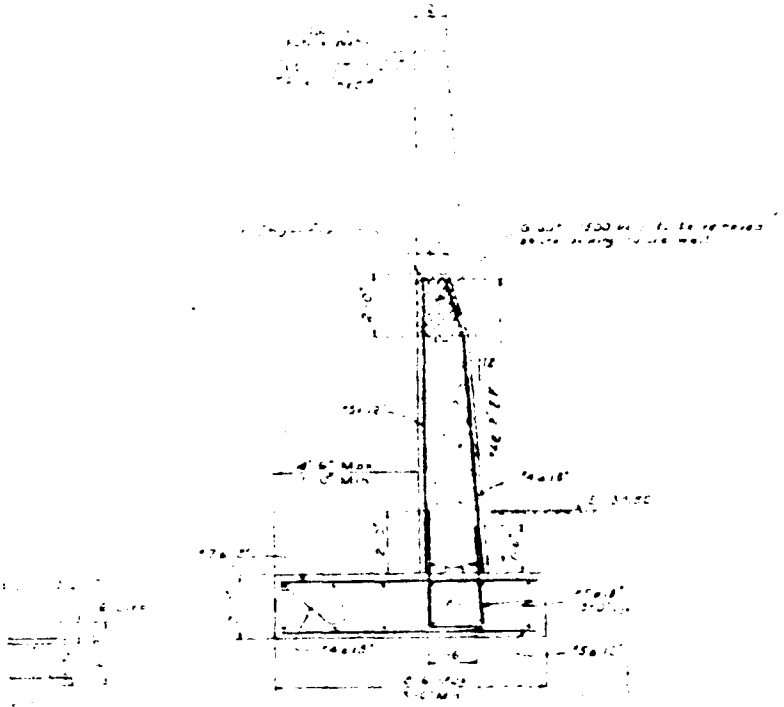
DETAIL "A"
Scale 1/2" = 1'-0"



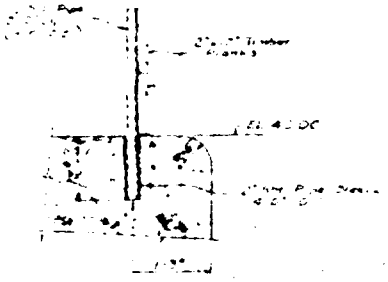
SECTION AT ℄ FISH LADDER
Scale 1/8" = 1'-0"

GENERAL NOTES -

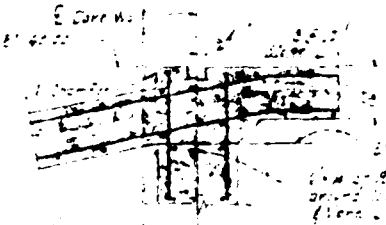
1. Footings may be altered, if necessary to suit conditions encountered in construction.
2. These notes shall apply to all concrete throughout the dam project and all other structures in the project applicable.
3. Use of construction joints other than those shown on the plans will require approval of the Engineers.
4. All reinforcing steel shall be intermediate grade deformed bars. Reinforcement splices shall be a minimum of 30 bar diameters except as noted on the plans, and shall conform to the provisions of ACI 318, except as to minimum lap. Reinforcement cover shall comply with the specifications unless otherwise noted on the plans.
5. Provide additional reinforcement diagonally in both faces around all openings with a dimension of 12" or greater. Steel shall be equal in diameter to the largest bar in the face concerned with a minimum size of #5.
6. Waterstops are not necessarily shown at every joint detail, but where they are shown, it is intended that they shall be complete and continuous throughout that particular structure. Waterstops in a vertical plane shall be carried to 6" below finished ground grade unless otherwise noted.
7. Control joints for excavation for structures shown on this drawing shall be installed only at the bottom of slopes of elevation [illegible] the bottom of the [illegible] structure as shown or required by [illegible] 12" [illegible] the vertical face of the [illegible].



SECTION B-B



FLASHBOARD DETAIL



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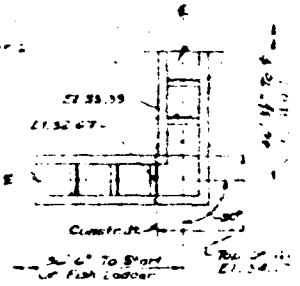
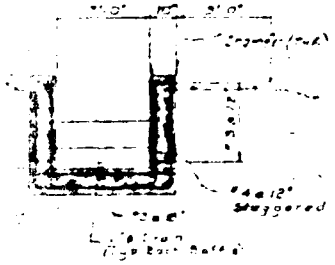
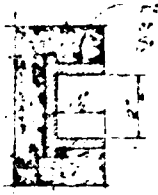


DETAIL "E" ⚠



SECTION D-D



SECTION E-E

DETAIL "C"

PROPOSED	
DAM AND RESERVOIR	
SCITUATE, MASSACHUSETTS	
SPILLWAY & FISH LADDER DETAILS	

1	Revised Fish Ladder	12-4-62
NO.	DESCRIPTION	DATE
	REVISIONS	

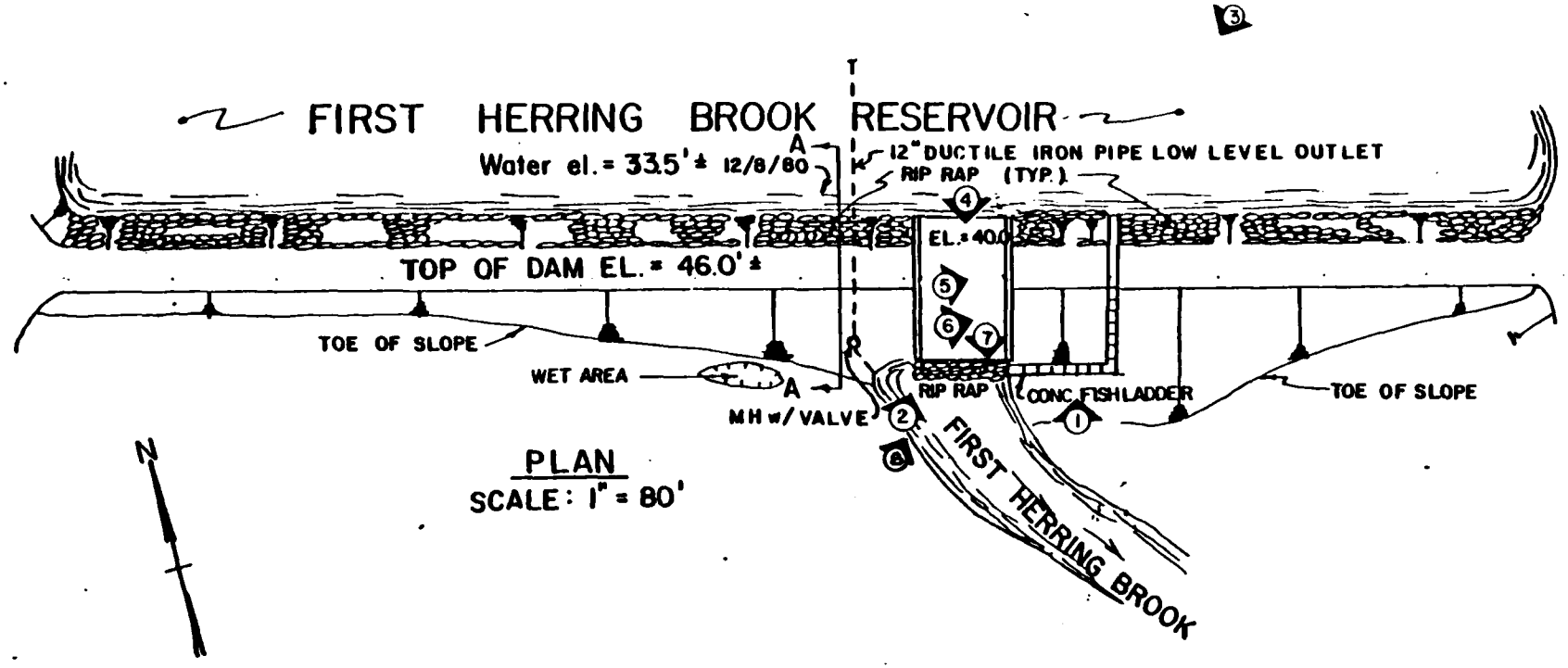
WHITMAN & HOWARD INC.
ENGINEERS AND ARCHITECTS
89 BROAD ST. BOSTON, MASS.

DESIGNED BY R.D.	SCALE AS NOTED	DATE DEC. 1962
DRAWN BY T.C.	APPROVED	
CHECKED BY R.D.	JOB NO. 1.22	SHEET NO. 4 OF 4 SHEETS

APPENDIX C

PHOTOGRAPHS

FIGURE 3



DENOTES PHOTO NUMBER AND DIRECTION IN WHICH PHOTO WAS TAKEN

ASEC CORPORATION *CONSULTING ENGINEERS* BOSTON, MASS. FEBRUARY 1981	PHOTO LOCATION PLAN FIRST HERRING BROOK RESERVOIR DAM MA 00478	U.S. ARMY ENGINEER DIV. NEW ENGLAND *CORPS OF ENGINEERS* WALTHAM, MASS.

PHOTO # 1
EROSION AT DOWNSTREAM END
LEFT SPILLWAY WINGWALL

PHOTO # 2
SEEPAGE AT END OF RIGHT
SPILLWAY WINGWALL

U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM , MASSACHUSETTS ASEC CORP. CONSULTING ENGINEERS BOSTON , MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	FIRST HERRING BROOK RES. DAM TR. TO NORTH RIVER SCITUATE, MASSACHUSETTS MA 00478 DECEMBER 8, 1980

PHOTO # 3

UPSTREAM SLOPE SHOWING WEIR AND RIP-RAP

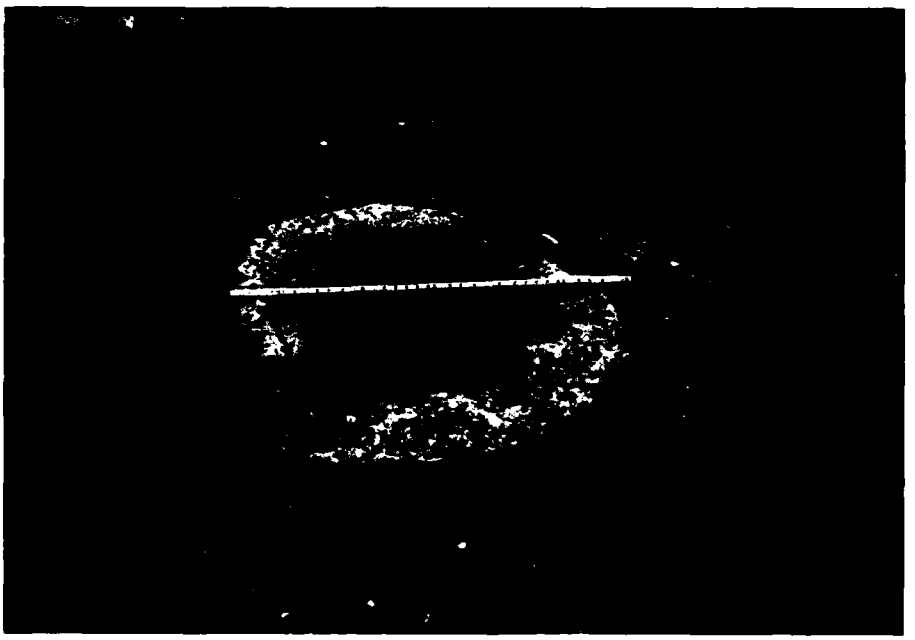


PHOTO # 4

SPALLED AREA ON WEIR CREST

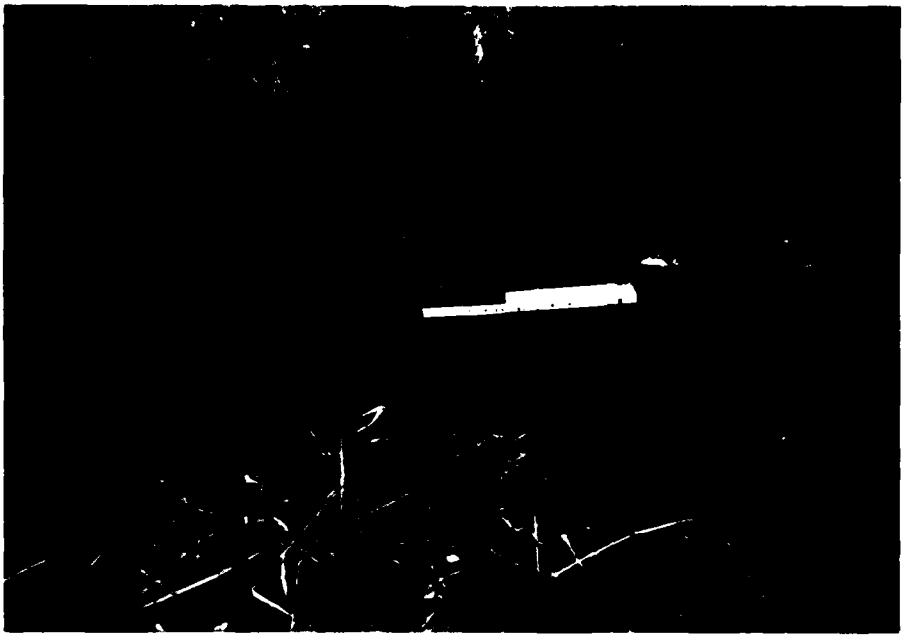


PHOTO # 5

CRACKS IN LEFT WINGWALL

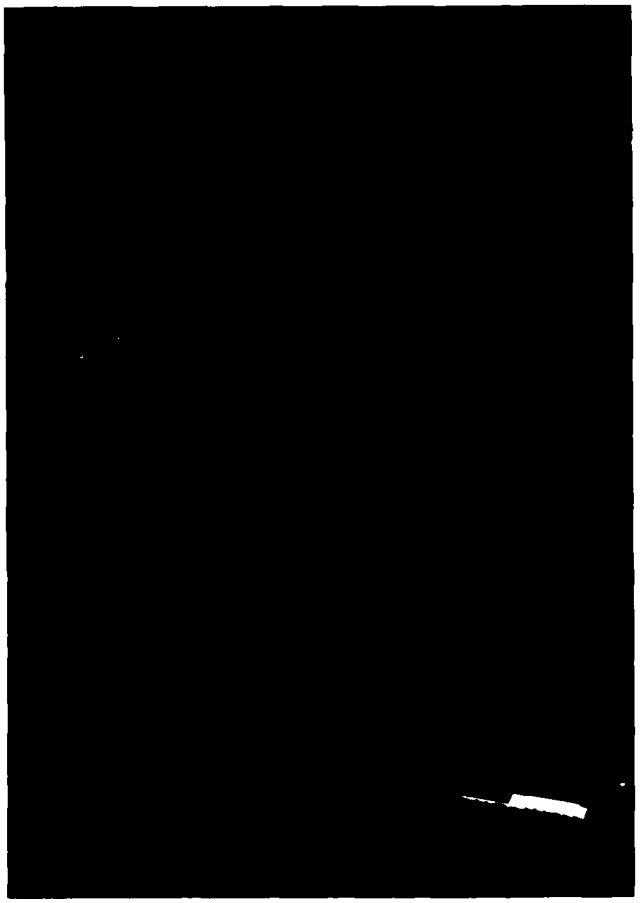


PHOTO # 6

STAINING AT CRACKS IN LEFT WINGWALL

PHOTO # 7 DOWNSTREAM CHANNEL

PHOTO # 8 SPILLWAY

U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM , MASSACHUSETTS	NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	FIRST HERRING BROOK RES. DAM TR. TO NORTH RIVER SCITUATE, MASSACHUSETTS MA 00478 DECEMBER 8, 1980
ASEC CORP. CONSULTING ENGINEERS BOSTON , MASSACHUSETTS		

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

First Herring Brook Reservoir Dam

Scituate, MA

Dam Rating Curve

A schematic sketch of the overflow section of this dam is shown in Figure 1. This sketch is based on plans obtained from the Town of Scituate. These plans are titled: "Proposed Dam and Reservoir, Scituate, Mass." and were developed by Whitman and Howard. Additional information obtained on a recent field inspection of the site was also used to construct the above sketch and was applied in the hydrologic and hydraulic analysis of the dam.

Spillway Discharge

$Q_1 = CLH^{1.5}$

C = 2.8 (Broad crested spillway)

L = 42'

H = head on spillway crest (datum elevation = 40.0' MSL)

$Q_1 = 2.8 \times 42 \times H^{1.5}$

Fish Ladder Discharge

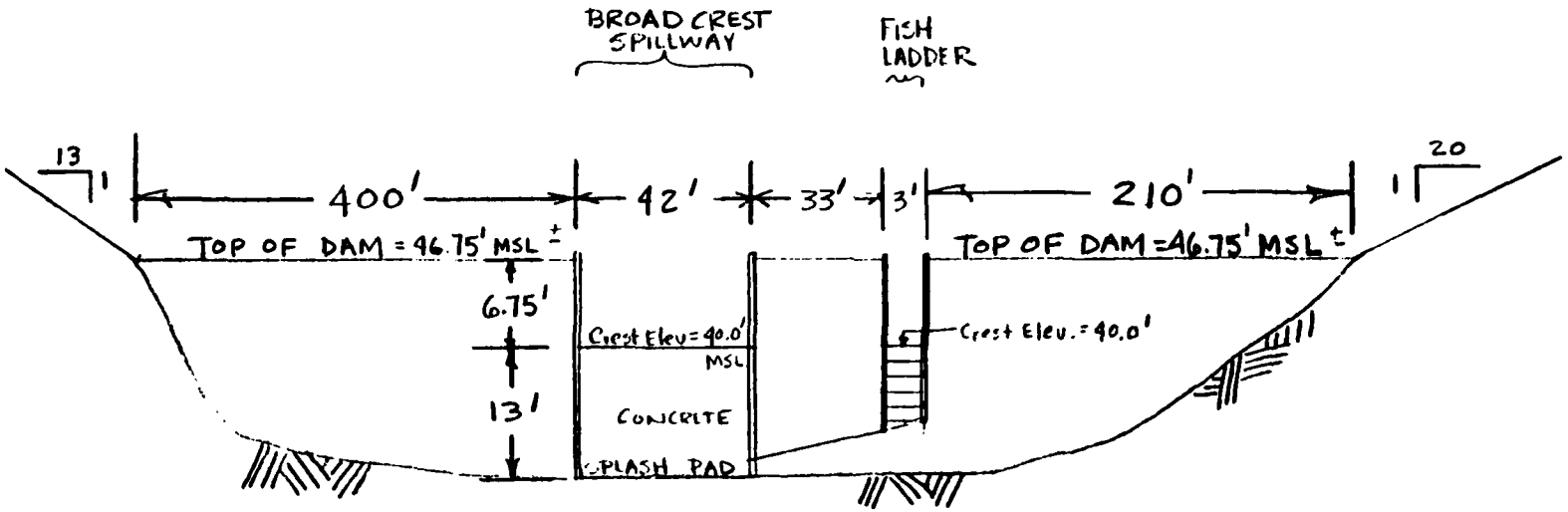
C = 3.3

L = 3.0'

H = same as on spillway crest

$Q_2 = 3.3 \times 3.0 \times H^{1.5}$

FIGURE #1



LOOKING UPSTREAM

SCHEMATIC OF FIRST HERRING BROOK RESERVOIR DAM

Dam embankment overflow discharge

$$Q_3 = Q_{\text{left embankment}} + Q_{\text{left side-slope}} + Q_{\text{right embankment}} + Q_{\text{right side-slope}}$$

Left embankment discharge

$C = 2.8$

$L = 210 + 33 = 243'$

$H = H - 6.75'$

$Q = 2.8 \times 243 \times (H - 6.75)^{1.5}$

Left side-slope discharge

$C = 2.8$

$L = 20 \times (H - 6.75)$

$H = (0.5 \times (H - 6.75))$

$Q = 2.8 \times (20 \times (H - 6.75)) \times (0.5 \times (H - 6.75))^{1.5}$

Right embankment discharge

$C = 2.8$

$L = 400'$

$H = H - 6.75'$

$Q = 2.8 \times (13 \times (H - 6.75)) \times (0.5 \times (x - 6.75))^{1.5}$

Total dam discharge

$$Q_{\text{total}} = Q_1 + Q_2 + Q_3$$
$$= 2.8 \times 42 \times H^{1.5} + 3.3 \times 3 \times H^{1.5} + 2.8 \times 243 \times (H - 6.75)^{1.5} + 2.8 \times (20 \times (H - 6.75)) \times (0.5 \times (H - 6.75))^{1.5} + 2.8 \times (13 \times (H - 6.75)) \times (0.5 \times (H - 6.75))^{1.5}$$

The above equation relating stage and discharge was implemented on a programmable calculator. Results are plotted on the stage-discharge curve for First Herring Brook Reservoir Dam (Graph 1).

Dam Failure Analysis

Dam Failure with Maximum Pool

Assume that the dam fails with the pool at maximum level, which corresponds to the elevation of the top of the embankment (46.75' MSL). The top of the embankment is 6.75 feet above the spillway crest and 19.75 feet above the downstream invert (below spillway).

Normal outflow at failure

Q = 2280 CFS (dam rating with H = 6.75')

Tailwater level at failure

Cross-sections located throughout the downstream impact area were coded and input into a HEC-2 multiple profile run using nine discharges covering the range of discharges expected during dam failure analysis. Results were used to construct stage-discharge and stage-cross-section area curves for each cross-section (see Graphs 2-7).

The following are locations of cross-sections used in the dam failure analysis:

Distance D/S of Dam (feet)	Normal Water Level (Ft MSL)
70	26
1150	24
2640	15
3670	15 (roadway @18)
4457	5 (roadway @9)
5300	4

Immediately preceding failure, the normal outflow of 2280 CFS results in a tailwater depth of 5.3 feet (graph 2) at the section located near the toe of the dam embankment, which is 70 feet downstream of the spillway crest. In other words, the tailwater would be at 30.3 feet MSL, which is 9.7 feet below the spillway crest or 16.5 feet below the headwater level.

Breach Outflow

$$Qp_1 = 8/27 \times W_b \times \sqrt{g} \times Y_o^{1.5}$$

where:

W_b = width of breach

$\leq$ 0.4 x (width of dam at ½ height)

$\leq$ 0.4 x 400'

use W_b = 100'

Y_o = pool elevation - downstream invert = 19.8'

$Qp_1 = 8/27 \times 100\sqrt{g} \times 19.8^{1.5} = 14{,}802$ CFS

Total Outflow

$Q_{total} = 2280 + 14{,}802 = 17{,}082$ CFS

The table below gives pre-failure downstream stages resulting from entering each section's stage-discharge curve at a discharge of 2280 CFS (normal outflow at failure).

Section (Ft downstream of dam)	Pre-failure Stage (Ft MSL)
70	30.3
1150	26.6
2640	20.2
3670	20.0
4457	11.6
5300	11.5

Impounding capacities of reservoir

Pool at top of dam (maximum)

Volume = 967 acre-feet

Pool at 0.5 foot above spillway crest (normal)

Volume = 600 acre-feet

Downstream Flooding

At 70' downstream of dam

Prior to failure

depth = 4.3' (Graph 2, with Q = 2280 CFS)

After failure

depth = 12.8' (Graph 2, with Q = 17,082 CFS)

Reach from 70' downstream to 1150 feet downstream of dam

To estimate peak dam break flow at a distance 1150 feet downstream of dam, we followed (essentially) the COE "Rule of Thumb Guidance for Estimateing Downstream Dam Failure Hydrographs."

Use stage-discharge and stage-cross-section area curves for sections 70' and 1150' downstream of dam (Graphs 2 and 3).

Storage volume in reach-versus-outflow

Assume channel and overbank storage of the flood wave is equal to the reach length times the average of the upstream post-failure flow area minus the upstream pre-failure flow area and the downstream post-failure flow area minus the downstream pre-failure flow area.

$$\text{Volume } (Ft^3) = \left[\frac{((A_{p1} - A_{N_1}) + (A_{p1} - A_{N_2}))}{2} \right] \times L$$

where: A_{p1} = post-failure u/s cross-sectional flow area (Ft^2)

A_{N_1} = pre-failure u/s cross-sectional flow area (Ft^2)

A_{p_2} = post-failure d/s cross-sectional flow area (Ft^2)

A_{N_2} = pre-failure d/s cross-sectional flow area (Ft^2)

L = reach length in feet

The attenuation of dam failure flow due to storage in the reach between 70' and 1150'd/s:

$$Q_2 = 2280 + Q_{p_1}\left(1 - \frac{V_1}{5}\right) = 2280 + 14{,}802\left(1 - \frac{V_1}{900}\right)$$

where: V_1 = volume of storage in reach, above pre-failure stage (acre-feet)

S = storage in reservoir before failure (acre-feet)

Q_{p_1} = breach outflow at upstream end of reach

Q_2 = total outflow at downstream end of reach after dam failure

The attenuation of peak dam failure flow at the downstream end of this reach is calculated on Graph 8. It can be seen from Graph 8 that the attenuation in the first reach has a negligible effect on stage at the downstream end of the reach (section 1150). The attenuated peak failure flow at 1150' d/s of the dam is 16,380 CFS with a corresponding stage of 30.1'. This post-failure stage is 3.5' above pre-failure stage and 6.1' above normal stream level.

There are five houses located about 1000' d/s of the dam. As their ground floor elevations are at about 31 to 33 feet above MSL, they will not experience flooding. However, one house located on the right overbank (looking d/s) about

1200 feet d/s of the dam will experience 2-3 feet of flooding (ground floor at 27'-28' MSL). This house would receive some damage, but only a small threat of loss of life is expected.

Between 1150' and 2640' d/s of the dam, the flood-plain widens out somewhat and the stream flows into Old Oaken Bucket Pond. There are 12 houses located off both sides of the brook in this reach.

The attenuation of peak failure discharges in this reach between 1150' and 2640' d/s of the dam are calculated on Graph 9.

By the end of this reach the peak failure flow is attenuated to 15,314 CFS with a corresponding stage of 23.0 feet MSL, which corresponds to a 2.8' increase over pre-failure stage and a 8.0' increase over normal stream level.

Assuming a linear peak failure profile from 30.1' at the upstream end to 23.0' at the downstream end of this reach, dam failure will result in shallow flooding (1-3 feet) at 10 of the 12 houses along this reach. This flooding would cause some damage to the houses, but would present only a small threat of loss of life.

After entering Old Oaken Bucket Pond, First Herring Brook flows through the pond and outlets at its south end through 2 culverts under Country Way Road, which is 3670' d/s of the dam. There are numerous houses, several commer-

cial structures and one Scituate Water Department Pump Station located around the south end of Old Oaken Bucket Pond.

The attenuation of peak failure discharge in the reach between 2640' and 3670' d/s of the dam is calculated on Graph 10.

The peak failure flow is attenuated to 14,275 CFS by the time it reaches the outlet of Old Oaken Bucket Pond (section 3670' d/s of dam). The corresponding failure stage at 3670' d/s of dam is 23.0', which is 3.0' above pre-failure stage of 20.0 feet and 8.0 feet above normal stream level. This will result in overtopping of Country Way Road with probable failure of the two culverts and the roadway embankment. About 7 houses will receive from 1-3 feet of flooding and 4 houses will receive from 3-4 feet of flooding. The Town of Scituate Water Department Pumping Station located at the outlet of Old Oaken Bucket Pond will receive major damage and 3 commercial structures will receive from 1-3 feet of flooding.

If the dam were to fail at a time when this area was congested with auto traffic and commercial business use, there would be a significant possibility of the loss of a few lives. In addition, significant damage would be incurred by numerous residential and commercial structures.

The attenuation of peak failure discharge in the next reach, which extends from 3670' to 4457' d/s of the dam is calculated on Graph 11.

The peak failure flow is attenuated to 13,490 CFS by the time it reaches Driftway (4457' d/s of dam). The corresponding failure stage at Driftway is 19.8' MSL, which is 8.2' above pre-failure stage and 14.8' above normal stream level. This will result in overtopping of Driftway with probable failure of the culvert and roadway embankment. One commercial structure located about 3900' d/s of the dam (200' d/s of Country Way Road) will receive from 3-6 feet of flooding, resulting in major damage and a possibility of loss of a few lives.

The attenuation of peak failure discharge in the next reach, which extends from Kent Street (4457 d/s of dam) to the point where the floodplain opens out into the extensive Herring Brook/North River Salt Marsh System (5300' d/s of dam) is calculated on Graph 12.

The peak failure flow is attenuated to 12,100 CFS by the time it reaches the downstream end of this reach (5300' d/s of dam). The corresponding failure stage is 19.0' MSL, which is 7.5' above pre-failure stage and 1.5' above normal stream level.

There are 5 houses which will receive flooding within this reach in the event of dam failure. Three of these houses will receive from 1-3 feet of flooding, with minor damage and a small chance of loss of life. Two more of these houses will receive from 3-7 feet of flooding with some chance of loss of life. Downstream of this reach,

peak failure discharges and corresponding stages will be quickly attenuated to insignificant levels due to extensive storage in salt marsh areas.

Test Flood Analysis

Size Classification: SMALL (storage between 50 and 1000 acre-feet; height < 40 ft.)

Hazard Classification: High (based on the possible loss of more than a few lives and appreciable economic loss - about 30 homes, the Town of Scituate Pump Station, Country Way Road and Driftway)

According to COE "Recommended Guidelines" the hazard and size classifications of the dam indicate a test flood between the 1/2 PMF and PMF.

Since the dam is relateively low in height, we will use the 1/2 PMF. Due to the topography of the land we consider the 500 yr. flood to give a reasonable approximation of a 1/2 PMF for this dam.

The U.S.G.S. Regional Equations for Eastern Massachusetts were applied to the drainage area above the dam to determine the 500 year peak discharge reaching the reservoir.

Drainage area = 4.44 square miles
Main Channel Slope = 18.9 ft./mile

$Q_{500} = 82.10 \times A^{0.798} \times S_1^{0.280}$

$Q_{500} = 614$ CFS

PMF from COE "Preliminary Guidance" = 820 CFS

Stage Storage Curve

The storage at the spillway crest (h = 0, 40' MSL) is 535 acre-feet. The reservoir surface area at elevation 40.0 MSL is 64 acres. Assuming this surface area and no

spreading as the reservoir rises:

Surcharge Storage = 64h

Total Storage = 535 + 64h

For the drainage area of 4.44 square miles or 2841 acres:

$$1\text{" of runoff} = \frac{2841(1")}{12"/\text{foot}} = 236.8 \text{ acre-feet}$$

1 acre-foot = 1/236.8 = .0042" of runoff

Surcharge Storage to the dam crest

= 6.75(64) = 432 acre-feet = 1.8" of runoff

At the dam crest, total storage is 535 + 432 =

967 acre-feet.

The stage-surcharge storage curve is given on Graph 13.

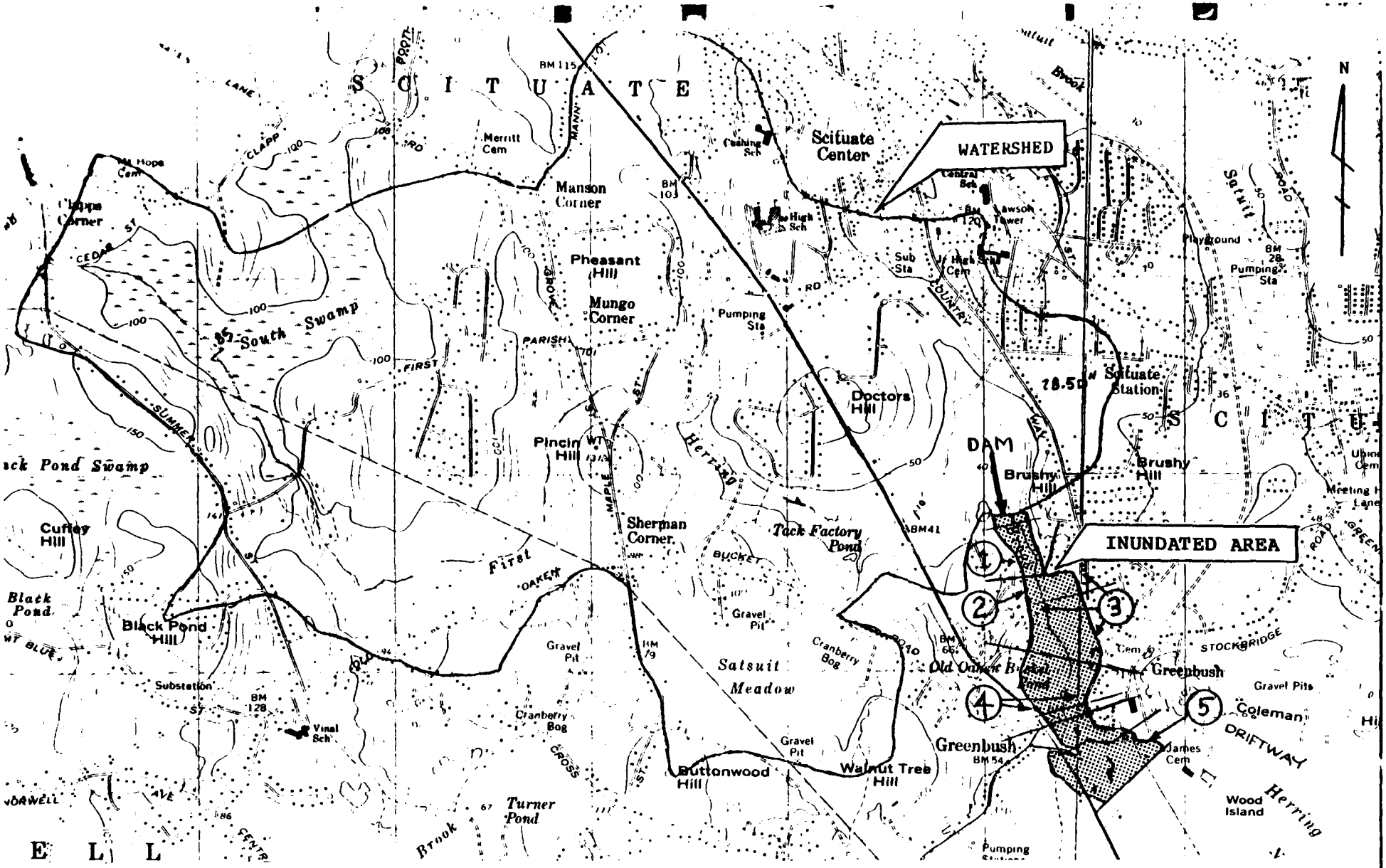
The attenuation of the test flood inflow due to storage in the reservoir is calculated on Graph 14.

The peak test flood outflow is 510 CFS, with a corresponding stage of 42.5' MSL, which is 2.5' above spillway crest and 4.25' below the dam crest.

The spillway can easily handle test flood discharge without overtopping of the dam embankments.

The table below summarizes the downstream effects of failure of First Herring Brook Reservoir Dam:

Location No. (see map)	Distance D/S of Dam (ft)	Number of Structures	Level Above Stream (ft)	Flow (CFS) Stage(Ft. above Stream) Before Failure	Flow (CFS) Stage(Ft. above Stream) After Failure	Comments
1	1150	5 houses	7-9	2280 2.6	16,380 6.1	
2	1200	1 house	4			Some damage to 1 house Little danger of loss of life
3	2640	7 houses 3 houses	7 5	2280 5.2	15,314 8.0	Some damage to 10 houses Little danger of loss of life
4	2640- 3600	7 houses 4 houses	5-7 4-5	2280 5.0	14,275 8.0	Some damage to 11 houses
	3670	pump station	3			Major damage to pump station
	3670	2 commercial buildings	5-7			Minor damage to 2 stores
	3670	1 professional building	5			Some damage to professional building Some danger of loss of life
Country Way Rd.	3670	road	3			Probably washed out
Driftway	4457	road	4	2280	13,490	Probably washedout
	3900	1 commercial building	9-12	6.6	14.8	Major damage to commercial building Some danger of loss of life
5	4457- 5300	3 houses	12-14	2280 7.5	12,100 15.0	Minor damage to 3 houses Little danger of loss of life
		2 houses	8-12			Major damage to 2 houses Some danger of loss of life
Salt Marsh	5500-					Flood wave completely attenuated No damage to property No risk of loss of life



WATERSHED PLAN / CROSS SECTION LOCATIONS

FIRST HERRING BROOK RESERVOIR DAM
SCITUATE, MASSACHUSETTS

SCALE 1" = 2000'

STAGE-DISCHARGE CURVE

FIRST HERRING BROOK RESERVOIR DAM

STAGE-DISCHARGE TABLE

H(ft)	Q(cfs)
0	0
0.5	45
1	128
1.5	234
2	361
2.5	504
3	663
3.5	835
4	1020
4.5	1217
5	1425
5.5	1644
6	1875
6.5	2113
7	2417
7.5	3072
8	3878
8.5	4834
9	5924
9.5	7142
10	8483

CFS

7000

6000

5000

4000

3000

2000

1000

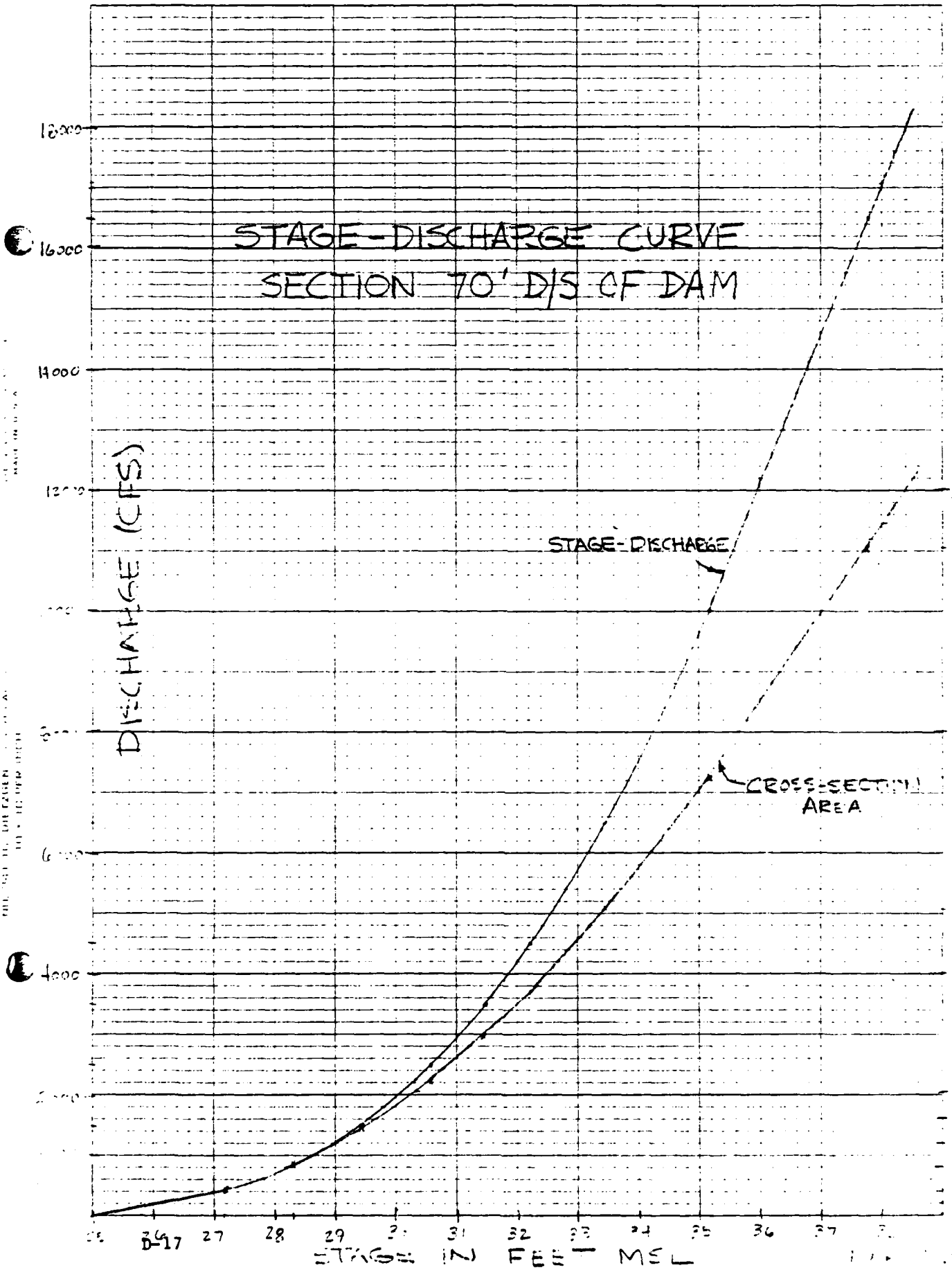
0

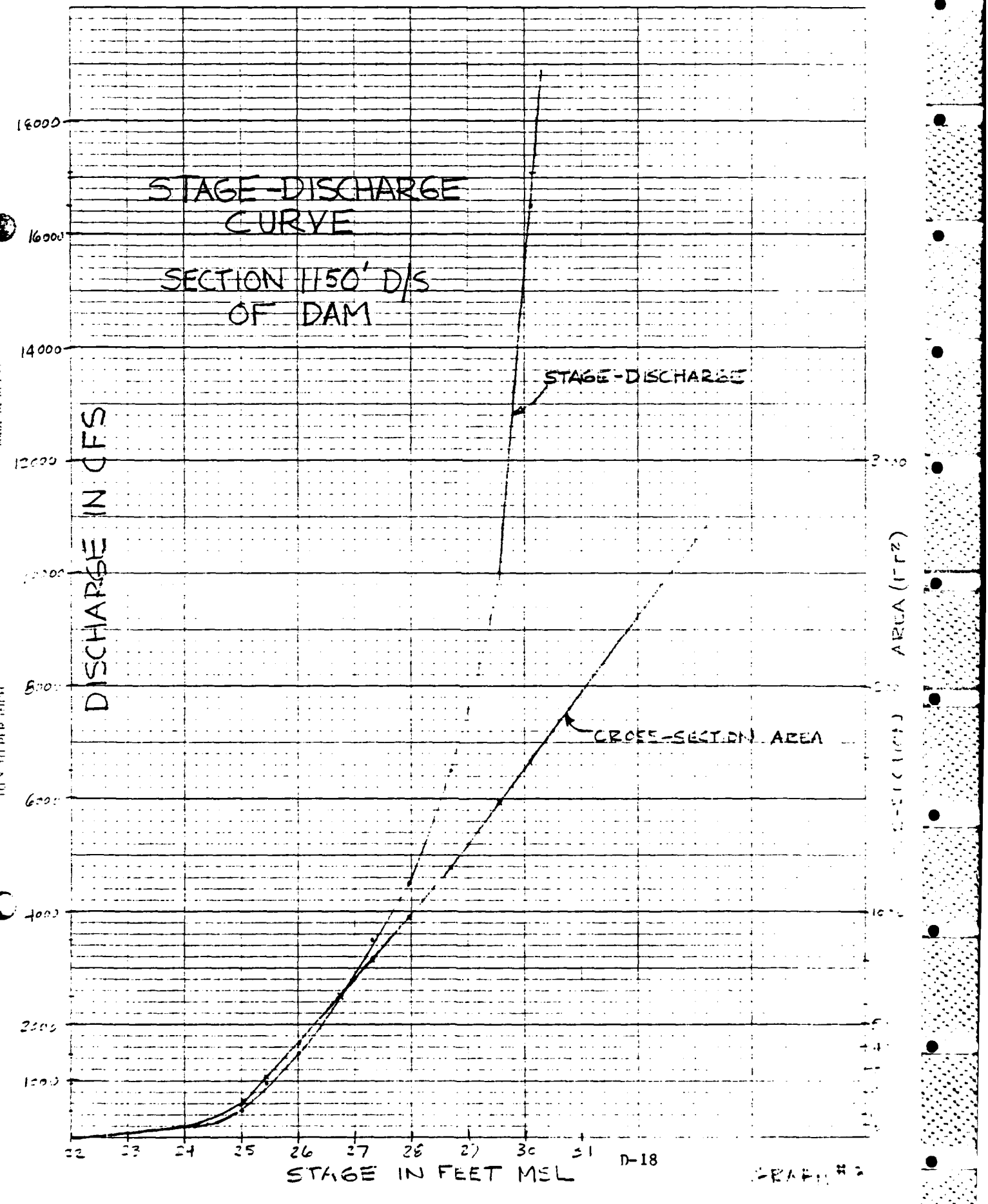
0 1 2 3 4 5 6 7 8 9 10

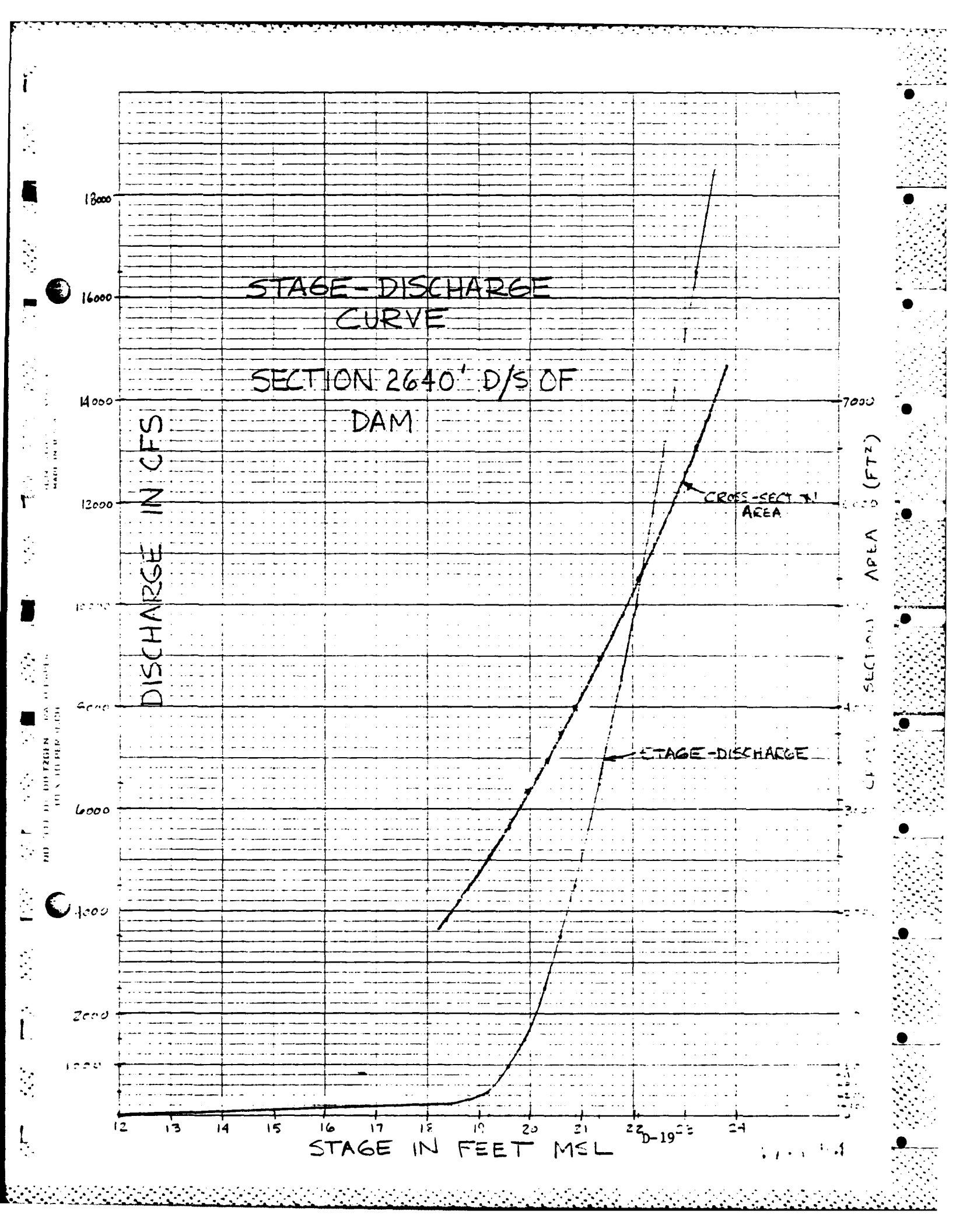
TOP OF DAM

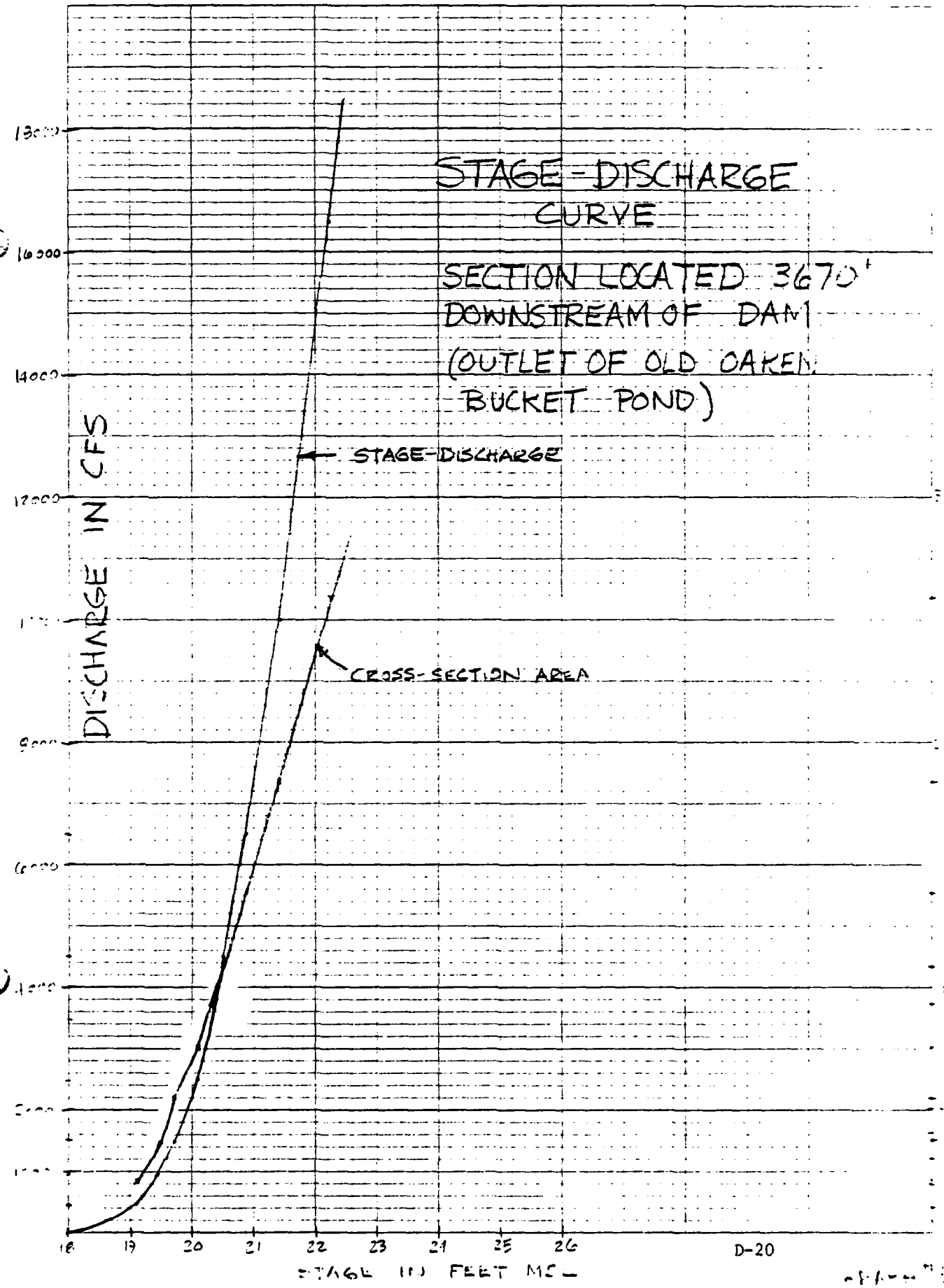
HEAD, H (FEET ABOVE SPILLWAY)

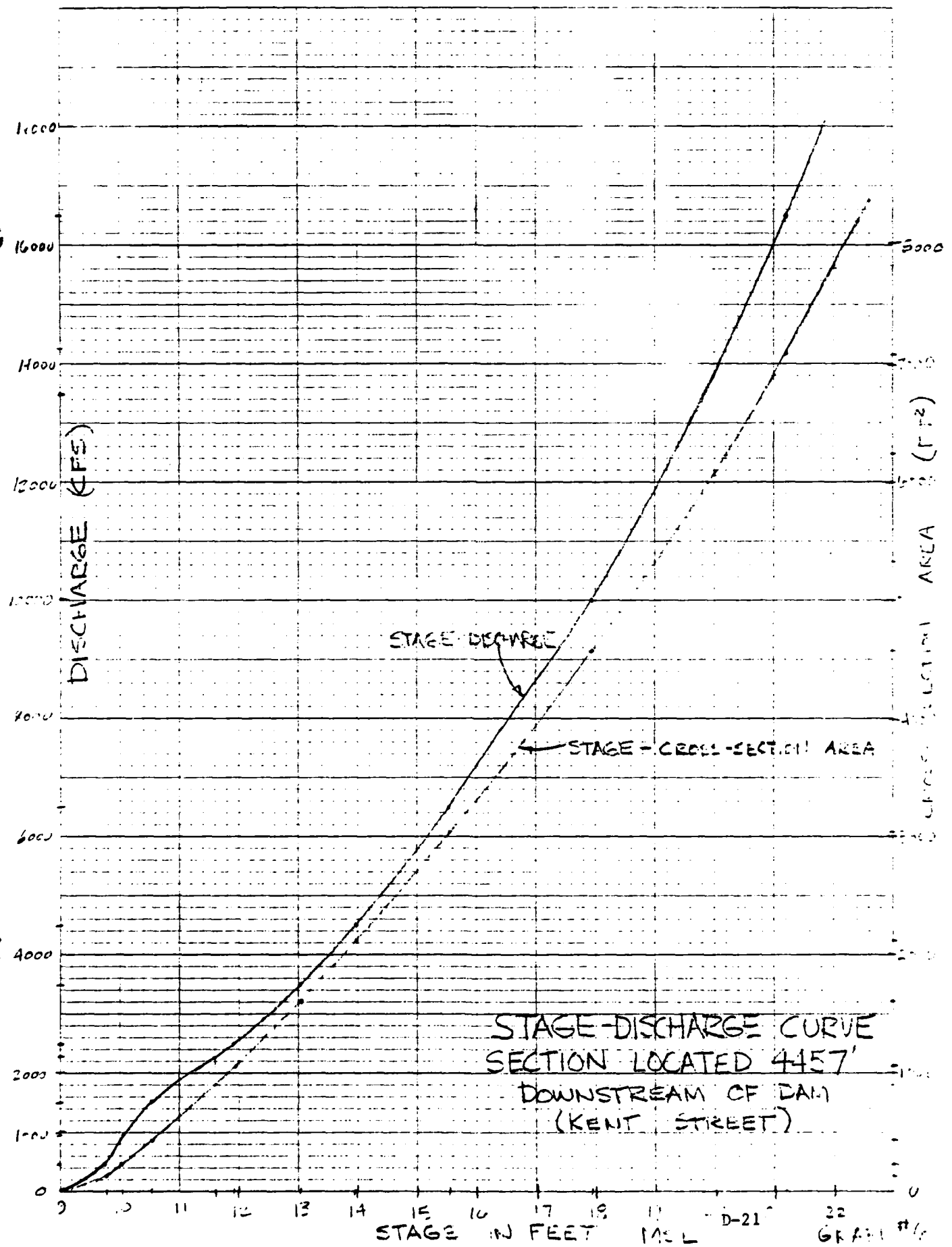
STAGE-DISCHARGE CURVE
SECTION 70' D/S OF DAM

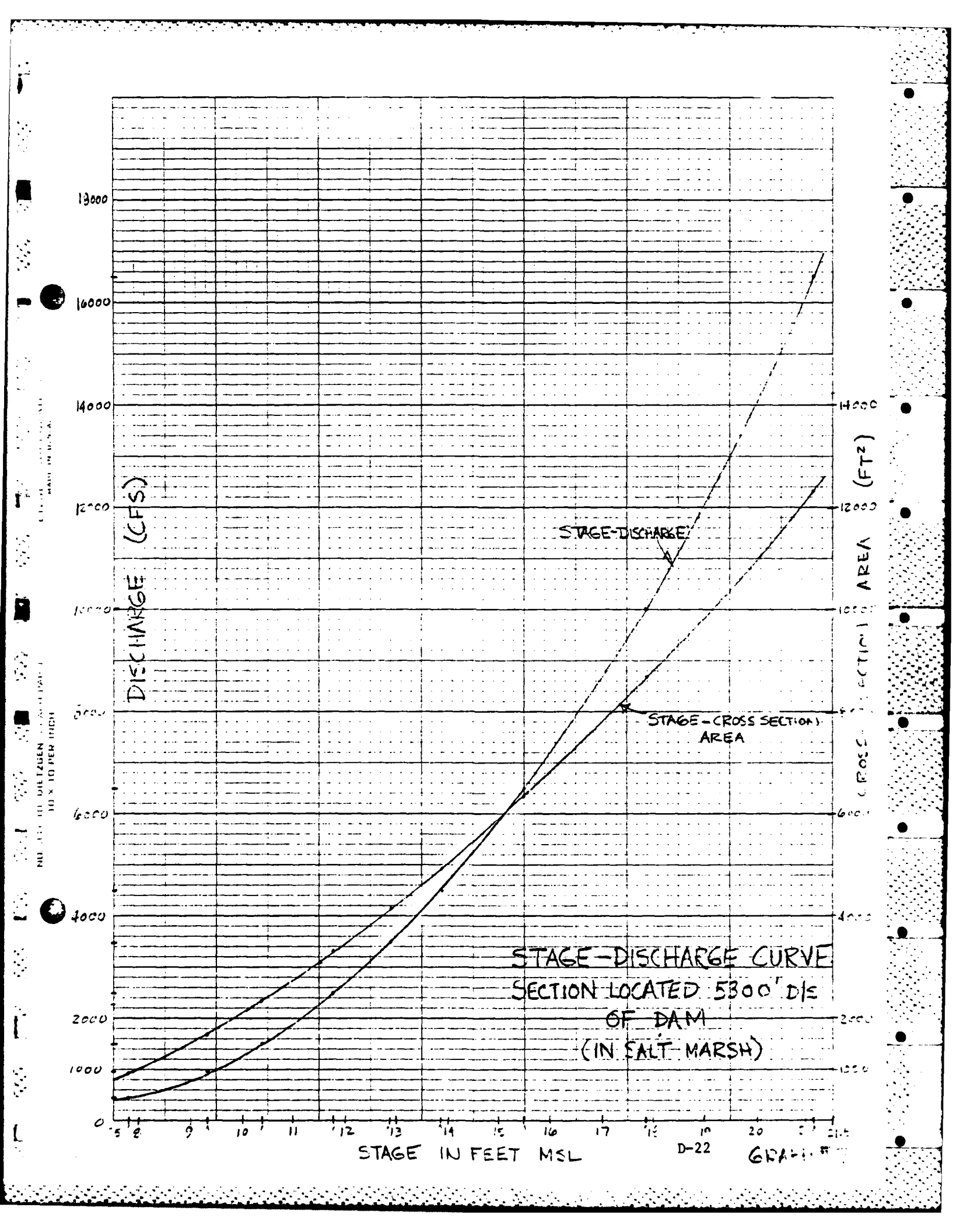



STAGE-DISCHARGE CURVE
SECTION 1150' D/S OF DAM
DISCHARGE IN CFS
STAGE-DISCHARGE
CROSS-SECTION AREA
AREA (FT²)
STAGE IN FEET MSL
16000
14000
12000
6000
4000
2000
1000
22
23
24
25
26
27
28
29
30
31


STAGE-DISCHARGE CURVE
SECTION 2640' D/S OF DAM
DISCHARGE IN CFS
18000
16000
14000
12000
6000
4000
2000
7000
CROSS-SECTIONAL AREA (FT²)
CROSS-SECT'N AREA
STAGE-DISCHARGE
12
13
14
15
16
17
18
19
20
21
22
23
24
STAGE IN FEET MSL


STAGE-DISCHARGE CURVE
SECTION LOCATED 367' DOWNSTREAM OF DAM (OUTLET OF OLD OAKEN BUCKET POND)
STAGE-DISCHARGE
CROSS-SECTION AREA
DISCHARGE IN CFS
16000
14000
12000
18
19
20
21
22
23
24
25
26
STAGE IN FEET MSL


DISCHARGE (CFS)
STAGE DISCHARGE
STAGE - CROSS-SECTIONAL AREA
STAGE IN FEET MSL
STAGE-DISCHARGE CURVE
SECTION LOCATED 4457'
DOWNSTREAM OF DAM
(KENT STREET)
D-21


DISCHARGE (CFS)
13000
16000
14000
12000
4000
2000
1000
0
STAGE-DISCHARGE
STAGE-CROSS SECTIONAL AREA
AREA (FT²)
14000
12000
6000
4000
2000
STAGE-DISCHARGE CURVE
SECTION LOCATED 5300' D/S
OF DAM
(IN SALT MARSH)
5
8
9
10
11
12
13
14
15
16
17
18
20
STAGE IN FEET MSL
D-22

ATTENUATED PEAK FAILURE FLOW AT 1150' D/S OF DAM

STAGE (FT)	AREA ABOVE PRE-FAILURE STAGE (FT²)	STORAGE VOL. (ACRE-FT)	Q_2 (CFS)
29.0	1300	37.9	16459
30.0	1640	42.1	16390
30.5	1800	44.1	16357

$Q_2 = 2280 + 14{,}802\,(1 - \frac{1}{3})$

STAGE-DISCHARGE CURVE

SECTION 1150' D/S OF DAM

Q_2 VS STAGE

$Q_2 = 16380$ CFS

STAGE = 30.1 FEET

STAGE-DISCHARGE

CROSS-SECTIONAL AREA

DISCHARGE IN CFS

16000
14000
12000
10000
8000
6000
4000
2000
1000

22 23 24 25 26 27 28 29 30 31

STAGE IN FEET MSL

D-23

ATTENUATED PEAK DAM FAILURE FLOW AT 2640' D/S OF DAM

$Q_2 = 2280 + 14{,}100(I = \frac{1}{2})$

STAGE (FT)	AREA ABOVE PRE-FAILURE	STORAGE (ACRE-FT)	Q_2 (CFS)
22	1740	48.7	15887
23	2865	68.1	15617
24	4140	90.0	15314
			14970

STAGE-DISCHARGE CURVE

SECTION 2640' D/S OF DAM

$Q_2 = 15{,}314$ CFS
STAGE = 23.0 FT.

CROSS-SECTIONAL AREA

STAGE-DISCHARGE

DISCHARGE IN CFS

18000
16000
14000
12000
10000
8000
6000
4000
2000
1000

12 13 14 15 16 17 18 19 20 21 22 23 24

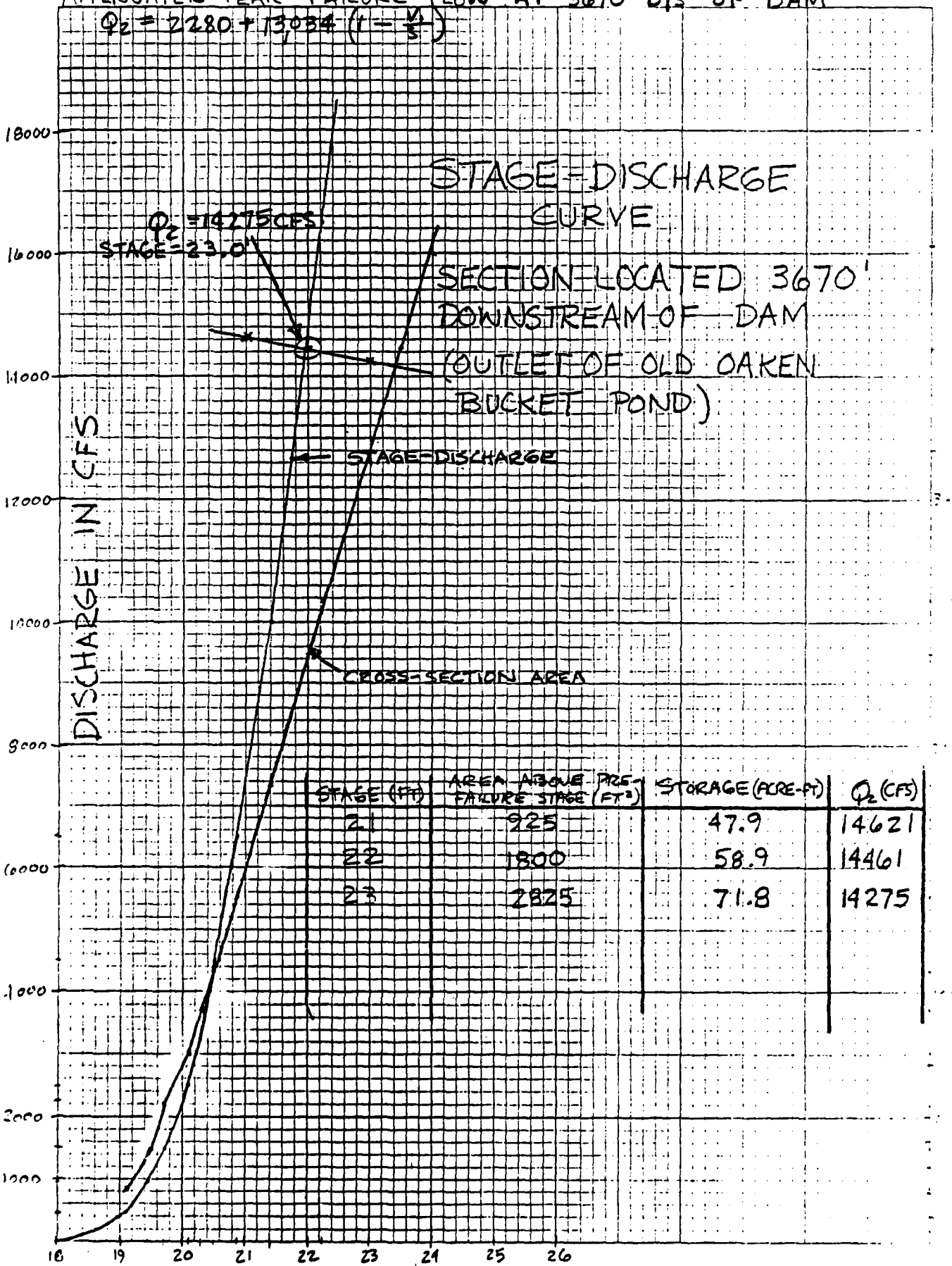
STAGE IN FEET MSL

D-24

GRAPH # 9

ATTENUATED PEAK FAILURE FLOW AT 3670' D/S OF DAM

$Q_2 = 2280 + 13,034\left(t - \frac{V}{S}\right)$



STAGE (FT)	AREA ABOVE PREV. FAILURE STAGE (FT²)	STORAGE (ACRE-FT)	Q_2 (CFS)
21	925	47.9	14621
22	1800	58.9	14461
23	2825	71.8	14275

GRAPH #10

ATTENUATED PEAK FAILURE FLOW AT KENT [illegible] (4157' d/s OF DAM)

$Q_2 = 2280 + Q_1 \left(1 - \frac{V_1}{S}\right) = 2280 + 11{,}?75 \left(1 - \frac{?}{?}\right)$

STAGE (FT.)	AREA ABOVE PRE-FAILURE STAGE (FT.²)	STORAGE (V_1) (ACRE-FT.)	Q_2 (CFS)
19	4420	55.0	13,542
20	5170	61.8	13,451
22	6930	77.7	13,239

STAGE = 19.8'
Q_2 = 13,490 CFS

DISCHARGE (CFS)

STAGE-DISCHARGE

STAGE-[illegible]

STAGE-DISCHARGE [illegible]
SECTION LOCATED [illegible]
DOWNSTREAM [illegible]
(KENT [illegible])

STAGE IN FEET MSL

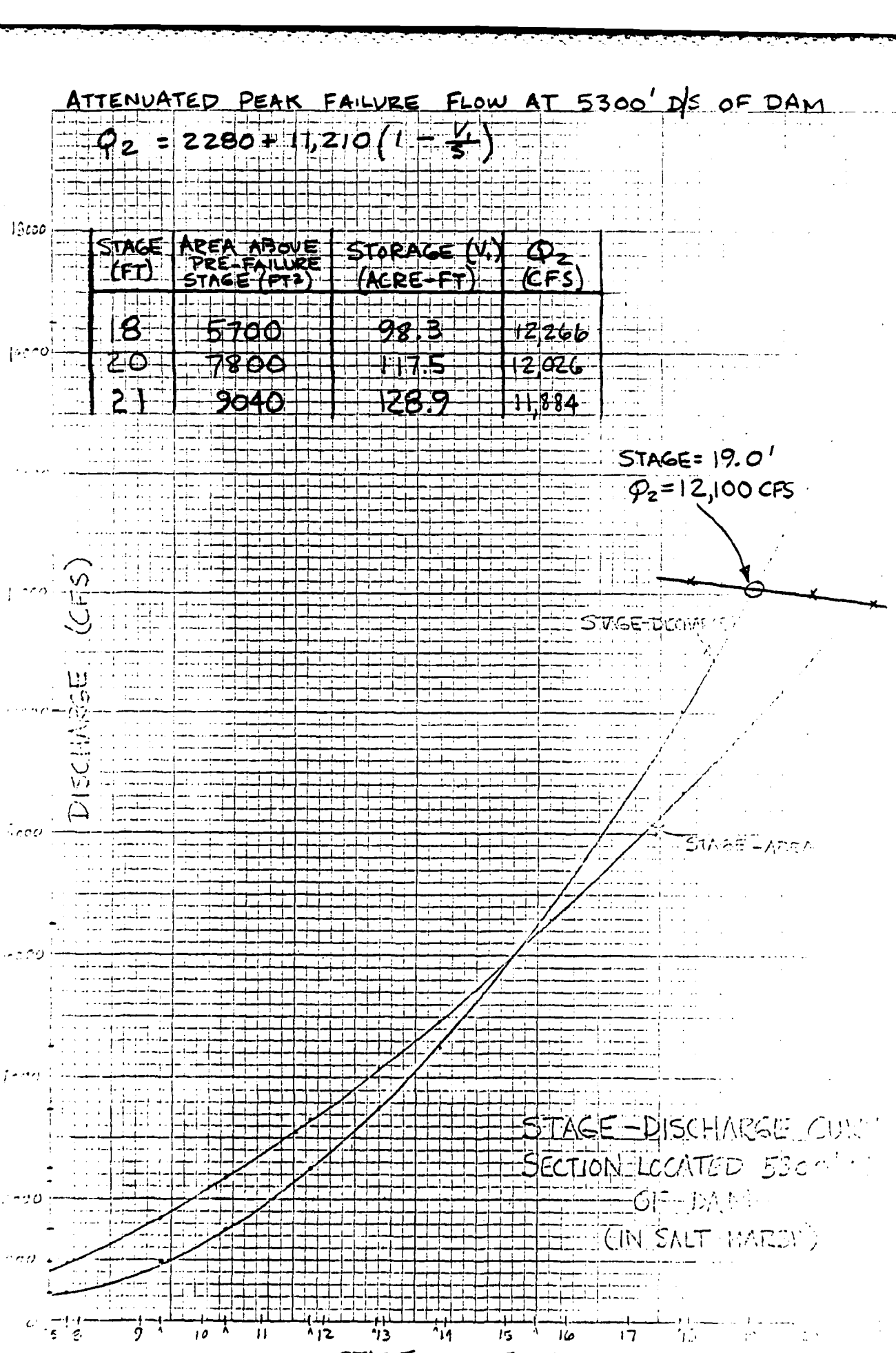
GRAPH #11

ATTENUATED PEAK FAILURE FLOW AT 5300' D/S OF DAM

$$Q_2 = 2280 + 11{,}210\left(1 - \frac{V_1}{5}\right)$$

STAGE (FT)	AREA ABOVE PRE-FAILURE STAGE (FT²)	STORAGE (V_1) (ACRE-FT)	Q_2 (CFS)
18	5700	98.3	12,266
20	7800	117.5	12,026
21	9040	128.9	11,884

STAGE = 19.0'
Q_2 = 12,100 CFS

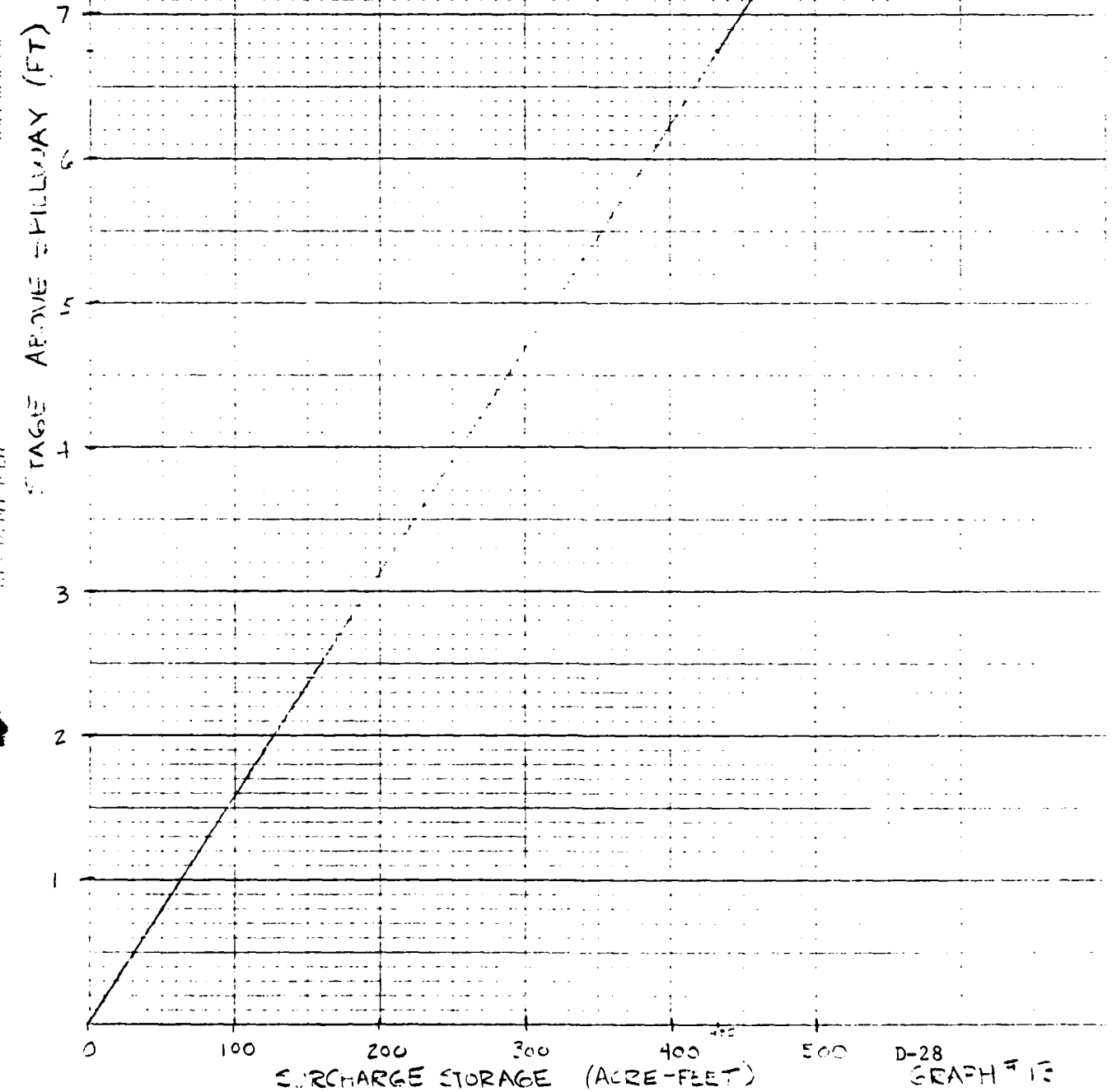


STAGE-DISCHARGE CURVE
SECTION LOCATED 530[illegible]
OF DAM
(IN SALT MARSH)

GRAPH #12

STAGE-SURCHARGE STORAGE CURVE

FIRST HERRING BROOK RESERVOIR DAM



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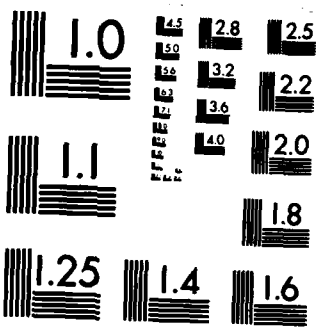
GRAPH # 12

AD-A154 733 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS 1/2
FIRST HERRING BROOK R.. (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV JUL 81

UNCLASSIFIED F/G 13/13 NL



ATTENUATED PEAK TEST FLOOD OUTFLOW AT FIRST HERRING BROOK DAM

$$Q_{P_2} = Q_{P_1}\left(1 - \frac{STOR}{9.5''}\right) = 614\left(1 - \frac{STOR}{9.5''}\right)$$

PMF R/O = 19"
500 yr = ½ PMF = 9.5"

STAGE DISCHARGE CURVE

FIRST HERRING BROOK RESERVOIR DAM

STAGE DISCHARGE TABLE

H (ft)	Q (cfs)
0	0
0.5	45
1	124
1.5	234
2	361
2.5	504
3	663
3.5	835
4	1020
4.5	1217
5	1425
5.5	1644
6	1873
6.5	2113
7	2361
7.5	2617
8	2878
8.5	3144
9	3414
9.5	3687
10	3963

STAGE (FT. ABOVE SPILLWAY)	SURCHARGE STORAGE (ACRE-FEET)	STOR (SUR. STOR x 0.092" (INCHES OF RUNOFF))	Q (CFS)
2	128	1.1	543
4	256	2.2	472
6	384	3.3	401

STAGE-VS-Q_{P_2}

Q_{P_2} = 510 CFS
STAGE = 2.5 FT.
ABOVE CREST
OF SPILLWAY

TOP OF DAM

DISCHARGE - CFS

HEAD, H - (FEET ABOVE SPILLWAY)

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GRAPH #14

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS

NOT AVAILABLE AT THIS TIME

END

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DTIC